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AIRCRAFT SYSTEM OPERATING AND SUPPORT COSTS: GUIDELINES FOR ANA--ETC(U)
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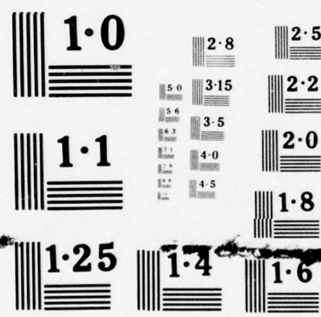

NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

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FIGURE 1. AIRCRAFT LIFE CYCLE

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AIRCRAFT SYSTEM
OPERATING AND SUPPORT COSTS:
GUIDELINES FOR ANALYSIS

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PREFACE

The Office of the Secretary of Defense, the Military Departments and defense contractors have for some time been actively concerned about rising life cycle costs (LCC) of Defense weapon systems.

Over the past two years, the Department of Defense (DoD) has placed new emphasis on examining the projected operating and support (O&S) costs of planned weapons and finding ways to reduce those costs. O&S cost analyses are now a major part of the cost review conducted at each weapon procurement decision meeting by the Defense Systems Acquisition Review Council (DSARC) and the DSARC's principal advisor on new system costs – the Cost Analysis Improvement Group (CAIG).

In support of the DSARC/CAIG review of system O&S cost impacts, LMI was assigned the task: "Life Cycle Cost Analysis in Support of the DSARC." The goal of the task was to develop O&S cost review procedures and estimating methodologies that the DSARC/CAIG will find useful in assessing the cost-effectiveness of new weapon systems.

This report is a product of the task. It contains guidelines for use in examining the cost impacts of new fixed and rotary wing aircraft systems and an aircraft maintenance cost estimating technique that can be used to conduct O&S cost tradeoff anlayses among competing new systems. The guidelines and technique are recommended to the CAIG as a basis for updating their aircraft O&S cost development guide, initially published in May 1974. Cost analysts in the Military Departments should, therefore, find them a useful preview of forthcoming DSARC/CAIG and OSD requirements for O&S cost analysis. Defense contractors should find them useful in carrying out weapon system cost analyses.

A section on micro-cost analyses describing procedures for conducting in-depth reliability versus support cost analyses, is included in the report only to indicate the type of analysis that can be conducted to determine the cost effectiveness of alternative

aircraft components. While the results of such analysis are useful to the Military Departments and to contractors for making detailed weapon configuration decisions, they generally are not applicable to the broad-base review requirements of the DSARC/CAIG.

The overall intent of this report is to contribute conceptually to aircraft system O&S cost analysis. Subsequent reports will deal with ship and combat vehicle cost reviews and estimating procedures.

ACKNOWLEDGEMENTS

In the preparation of this report, the authors had the benefit of numerous constructive comments and reviews from persons in the Office of the Secretary of Defense, the Military Departments, defense industry, RAND, and LMI. At OASD(I&L)(WR), Messrs. Russell Shorey, Al Frager, Ed Cresswell, and Martin Meth had a fundamental role in planning and developing the study. Al Frager was a virtual participant in the preparation of this report. As a member of the CAIG, Mr. Frank Swofford in OASD(P&E) was very helpful in his review of content and structure. Particularly useful reviews were received from Messrs. Russell Genet and Perry Stewart, Major Jon Reynolds of the USAF, and Mr. Fred Carlson of the Boeing Aerospace Company. Within LMI, Messrs. Harold Denny, Paul Dienemann, Thomas O'Malley, Perkins Pedrick, and Luis Sanchez provided useful comments, and Dr. Margaret Grotte made an excellent editorial contribution. With full acknowledgement of the above, the authors take full responsibility for the content of this report.

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I. INTRODUCTION

A. PURPOSE

This report recommends guidelines for preparing and presenting estimates of the support investment (SI) and operating and support (O&S) costs of fixed and rotary wing aircraft systems to the Defense Systems Acquisition Review Council (DSARC). It provides a framework for objective comparison of SI and O&S costs of program, design, or support alternatives, using consistent methodologies and terminology. It also focuses on the assessment of efforts to control the downstream costs of weapon systems in the acquisition phase. A general methodology for SI and O&S cost-estimating is described, a standard cost element structure is defined, and specific requirements for presentation of SI and O&S cost estimates to the DSARC are proposed. Standards for the presentation and documentation of those cost estimates are recommended.

These guidelines are intended to achieve consistent and effective preparation and documentation of major weapon system SI and O&S cost estimates, and to facilitate DSARC's and the Cost Analysis Improvement Group (CAIG)'s examination of important SI and O&S cost issues. They should be understood as recommendations to the CAIG—a suggested contribution to updating of the official CAIG Cost Development Guide for *Aircraft Systems* originally published in May 1974.

B. AUTHORITY AND REFERENCES

The basis for development and review of life cycle cost (LCC) estimates within the DSARC is set forth in Department of Defense Directive (DoDD) 5000.1, "Acquisition of Major Defense Systems." The Directive requires the establishment of cost parameters for major defense system acquisitions that reflect the cost of acquisition and ownership. Further, "... discrete cost elements (e.g., unit production cost, operating and support cost, etc.), shall be translated into 'design to' requirements." DSARC's review and confirmation of LCC estimates are thus implied.

Within the concept of design-to-cost, the DoD intends that LCC objectives should be determined for each acquisition program. Although the initial design-to-cost goals were directed toward minimizing unit production costs, the reduction of future SI and O&S costs during design and development should also be an objective. Recent DoD guidance calls for the Military Departments to establish O&S cost targets for weapon systems in development, and to monitor progress toward these targets. The importance of evaluating the SI and O&S costs of new systems is recognized throughout DoD, and implementation of methods to evaluate LCC impacts is a major element of the DSARC process.[1]

The CAIG advises the DSARC on all matters pertaining to weapon system cost analysis, and is specifically responsible for establishing criteria, standards, and procedures concerning cost estimates, and determining what costs are relevant for consideration by the DSARC. Using the guidelines recommended in this report, the CAIG intends to update existing criteria, standards, and procedures for the preparation and presentation of cost estimates of major weapon systems for DSARC review and consideration.

C. APPLICABILITY

The guidelines recommended in this report apply to all fixed and rotary wing aircraft acquisition programs reviewed by the DSARC. They are generally applicable to any cost analysis performed during the acquisition process, including cost effectiveness and design trade studies.

These guidelines call for cost estimates reflecting costs that are variable with respect to acquisition program decisions; hence, the estimates are not the same as total program or budget costs, and contain only part of the information necessary for budget impact analysis. The guidelines are designed to allow the cost analyst freedom in the selection of cost-estimating techniques and models, and to satisfy the institutional requirements for standard conventions and minimum requirements.

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[1]See Appendix B, Section 5, for selected references which establish the need for SI and O&S cost estimates.

D. OVERVIEW

Sections II-VI present the DSARC requirements and a structure for aircraft SI and O&S cost analyses and presentations. Section II briefly reviews the DSARC process, and the type of information needed for analysis and review of major aircraft acquisition programs. Section III presents the basic methodology for performing aircraft SI and O&S cost analysis, describing the role of each major component, and establishing certain cost-estimating principles. The use of variable costs, pre-DSARC meetings, reference systems, system program definition statements (SPDS), the application of the cost element structure, and the presentation of the results are emphasized. Section IV recommends the cost element structure (CES) to be used in the SI and O&S cost analysis of aircraft systems. Designed to have multi-service applicability, the CES defines and categorizes those costs typically affected by DSARC decisions. The set of significant cost elements that should be central to any cost analysis effort is also identified. Section V discusses maintenance support requirements (MSR) analysis, which addresses trade-offs between cost and design parameters. The MSR analysis isolates the resource requirements related to system or design inherent characteristics, and operations or manning policies. Section VI describes the DSARC presentation requirements as a function of various uncertainties in the DSARC process, the status of the system design, and the SI and O&S cost analysis issues under consideration.

Section VII reinforces important aspects of the SI and O&S cost analysis process and illustrates some typical products. The importance of pre-DSARC meetings in tailoring the cost analysis to current acquisition program issues is emphasized. Next, a series of illustrations demonstrates various methods of presenting SI and O&S information to the DSARC. They include: SPDS, several approaches to presenting O&S cost trend and goal information, and examples of SI and O&S cost estimates. Examples of cost estimates are expressed in terms of the CES introduced in Section IV, and such concepts as the reference aircraft, and the baseline, current, and independent estimates for the proposed

aircraft. Section VII concludes with several examples of micro-analysis—MSR analyses, sensitivity analyses, and trade-off studies--that are frequently implicit in acquisition program decisions, but are presented to the DSARC only upon request, or when central to the issues being discussed. The themes of Section VII are: adjustment of the cost analysis to the acquisition program, clear and concise communication of the results to the DSARC, and the placement of those results in perspective, so that the DSARC appreciates the SI and O&S cost impact of program decisions.

II. THE DSARC PROCESS AND COST REQUIREMENTS

A. INTRODUCTION

DoDD 5000.1 places the responsibility for development and acquisition of major defense systems on the Military Departments and Defense Agencies. Decisions that initiate or increase program commitments are reserved for the Secretary of Defense (SecDef).

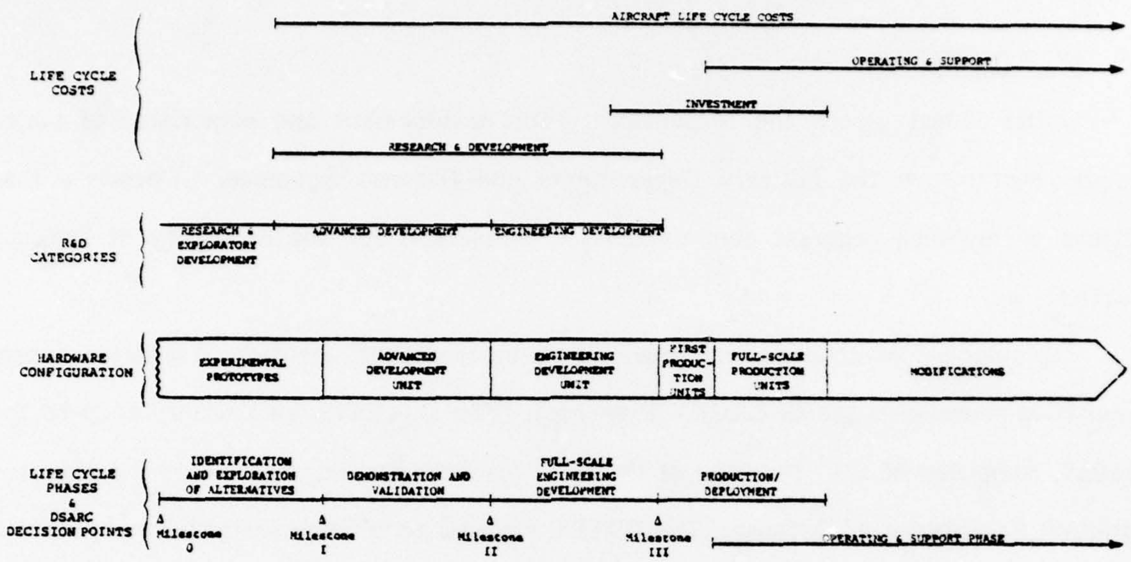
The principal mechanism for focusing DoD management attention on a major system acquisition program is the DSARC/DCP process. The DSARC is an advisory body to the SecDef, composed of the Director of Defense Research and Engineering, and designated Assistant Secretaries of Defense. The DSARC reviews acquisition programs and provides recommendations for SecDef decisions. The essential program information (e.g., needs, goals, schedule, costs, and risks) and the SecDef decisions are recorded in the Decision Coordinating Paper (DCP). The DCP is frequently referred to as a contract between the SecDef and the proponent Military Department or Defense Agency.

B. THE DSARC PROCESS

An acquisition program is initiated by a SecDef decision authorizing a Military Department to proceed with the identification and evaluation of alternatives to satisfy a stated mission need. Subsequent to program initiation, DSARC reviews are keyed to the major decision milestones of a program. These milestones mark the beginning of demonstration and validation (Milestone I), the commitment of resources to full-scale development (Milestone II), and initiation of production and deployment (Milestone III). Other DSARC reviews are scheduled as needed. The basic relationships of the DSARC decision points to LCC, R&D categories, and hardware configuration are shown in Figure 1.

Aircraft LCC start with initial R&D funding for advanced development, which permits completion of the conceptual phase. Milestone I marks the beginning of demonstration and validation and the first major financial commitment to the

FIGURE 1. AIRCRAFT LIFE CYCLE



development of a new aircraft. In some recent programs, demonstration and validation has concluded with a "fly-off" between competing advanced development aircraft, and the selection of a single contractor for engineering development. Approval at Milestone II initiates full-scale engineering development, during which the design configuration and characteristics of the aircraft are tailored to the operational needs of the Military Department. When engineering is complete, Milestone III addresses the production decision. Frequently, Milestone III will authorize a low rate of initial production, with full-scale production to be approved by a supplemental DSARC review.

The operating and support phase of an aircraft's life effectively starts with deployment of the first operational units, usually well after completion of the DSARC/DCP process. Yet, the major determinants of O&S costs are the decisions made during the DSARC/DCP process. DoD requires analysis of outyear costs during development, design, and procurement, with the objective of reducing its allocation for

the operation and support of aircraft. Consequently, an analysis of SI and O&S costs is required at each major decision milestone to assist the DSARC in verifying that:

- DoD can afford to operate and support the proposed aircraft once it is in the defense inventory
- Future O&S costs have been adequately considered in the selection of the proposed aircraft
- Positive action to reduce SI and O&S costs has been initiated in the system design and the development of support concepts
- Relevant historical O&S cost drivers have been explicitly considered in the design of the new system
- Significant trade-offs between cost and performance of alternative designs, support concepts, and acquisition strategies have been taken into account.

C. REQUIREMENTS FOR COST INFORMATION

The fundamental DSARC requirements for SI and O&S cost information are generated by DoD's need to verify that the proposed aircraft system is being designed, developed, and procured within reasonable constraints on performance, schedule, and LCC. In general, the cost information includes: an estimate of the SI and O&S costs of the proposed weapon system; presentation of clearly defined alternatives and the differences in their SI and O&S costs; comparisons between the estimated O&S cost of the proposed system and the historical O&S cost trends of similar, or mission-analogous, operational systems; a comparative analysis of the relevant historical O&S cost drivers, and their relative expected values for the proposed system; an analysis of the range of costs based upon the inherent cost estimating uncertainty; and a discussion of the O&S policies that will result in the lowest O&S costs for the new weapon system, commensurate with overall LCC and performance criteria.

The nature of the cost estimates and cost comparisons depends on the phase of the acquisition program, and the specific issues involved. At Milestone I, little about the

detailed design of the proposed weapon system is likely to be known. However, the affordability of a program must be judged, alternatives must be compared, and goals must be first established, all at this formative stage. The most significant impact on SI and O&S costs can be achieved at Milestone I. Initial SI and O&S cost estimates must be made for each alternative weapon system concept, and for the existing similar, or mission-analogous, system (usually the one to be replaced). Such estimates should reflect system and support concepts, mission requirements, and anticipated deployments.

Prior to the commencement of full-scale engineering development, SI and O&S cost estimates and cost comparisons ought to show increased accuracy, commensurate with more fully developed configurations and support concepts for the weapon system. By Milestone II, the subsystems most likely to influence SI and O&S costs, and those whose development is most uncertain should be identified. Logistics goals need to be established for these critical subsystems, and the sensitivity of SI and O&S costs to such goals evaluated.

The SI and O&S cost estimates prepared for Milestone III should be based on the current design characteristics of the weapon system, the schedule for introducing the system into the operating forces, and the initial and mature system support plans. The critical subsystems and associated logistics goals established prior to engineering development must be validated. To the extent feasible, experience from the test and evaluation program ought to be used to verify progress in meeting logistics goals, or to signal potential problem areas. When goals cannot be met, program alternatives and their respective impacts on O&S costs should be defined, evaluated, and presented to the DSARC.

III. BASIC METHODOLOGY FOR AIRCRAFT SI AND O&S COST ANALYSIS

A. INTRODUCTION

Section III presents a set of methodological principles and conventions to promote consistent SI and O&S cost analysis. The essential components of the process for developing and presenting such analyses to the DSARC are specified.

B. COST PERSPECTIVE

1. Cost Categories of Interest

The major LCC categories for a weapon system are outlined in Table 1. These recommended guidelines address only the SI and O&S categories, with the primary focus on O&S costs.

TABLE 1. AIRCRAFT LIFE CYCLE COST CATEGORIES

100	RESEARCH AND DEVELOPMENT	
200	INVESTMENT	
	201	Weapon System Investment
	202	Support Investment
300	OPERATING AND SUPPORT	
	301	Deployed Unit Operations
	302	Below Depot Maintenance
	303	Installations Support
	304	Depot Maintenance
	305	Depot Supply
	306	Second Destination Transportation
	307	Personnel Support and Training
	308	Sustaining Investments

The O&S cost categories (301, . . . , 308)[2] are basically compatible with those defined in each Military Department's Visibility and Management of Support Cost (VAMOSC) Systems for Aircraft. This compatibility supports an OSD objective to foster

[2] Cost elements within the major SI and O&S cost categories are discussed and defined in Section IV and Appendix A, respectively.

consistency between the cost analyses for the DSARC and the Military Departments' O&S Cost Analyses of operational weapon systems.

2. Relevant Variable Costs

The cost analysis in these recommended guidelines centers upon the major weapon system acquisition programs reviewed by the DSARC. Accordingly, the costs of interest are those that can be affected by OSD and Military Department actions during the DSARC process: the relevant variable costs. The objective is to specify all relevant variable SI and O&S costs to the government from both contractor and in-house activities, regardless of how such costs are funded. The O&S cost categories reflect the recurring costs required to operate and support the weapon system to achieve the desired capability over a specific operational lifetime.

The set of SI and O&S cost categories is intended to be a comprehensive definition of the relevant variable costs for the DSARC. However, future analyses are bound to introduce circumstances in which additional costs will be relevant. For example, collateral costs for such activities as base openings or closings, combat crew training, or aerial refueling could be pertinent to some aircraft acquisition programs. To cover these possibilities, the following rule should be applied:

> IF A DECISION WILL AFFECT COSTS NOT EXPLICITLY DESCRIBED BY THESE GUIDELINES, SUCH COSTS MUST BE IDENTIFIED, AND THEIR MAGNITUDE ESTIMATED, AND THEY MUST BE INCLUDED IN THE COST ANALYSIS.

3. Relationship to Planning, Programming and Budgeting

Cost estimates for planning, programming and budgeting address total costs. Because the cost analysis called for in these proposed guidelines pertains only to those portions of total costs that are variable with an aircraft acquisition program, the estimated SI and O&S costs will not necessarily be the same as program or budget costs. However, the information gained from these SI and O&S cost analyses should be

compatible with approved Program, Planning and Budgeting System (PPBS) costs, and can be used to derive the impact of alternative aircraft programs on programs and budgets.

C. COST ANALYSIS METHODOLOGY

Figure 2 outlines the basic cost analysis methodology for these suggested guidelines. The development and presentation of the cost analysis involves ten fundamental steps, organized into three groups. The major headings state the themes of the steps within each group. The arrows indicate the necessity for repeating individual steps and groups of steps to refine perceptions and assessments of critical issues. Most of the steps are standard components of systematic cost analyses, and should be familiar to experienced cost analysts.[3]

1. Defining the Pertinent Issues in the Pre-DSARC Meetings

Each acquisition program is likely to entail special cost analysis issues and problems. The analyses and presentations for the DSARC must be tailored to deal effectively with them. In accordance with published DoD policy, these proposed guidelines assume pre-DSARC meetings throughout the DSARC process. The CAIG Chairman and representatives of the Military Departments are the principals in these discussions, which are intended to improve the quality and relevance of the analyses and presentations.

The pre-DSARC discussions should cover:

- Description and characterization of the proposed system
- Description and characterization of an existing reference aircraft
- Specification of alternatives
- Identification of historically relevant SI and O&S cost drivers for the proposed system, and actions planned to reduce them
- Identification of the unique properties of the proposed system that could affect SI and O&S requirements

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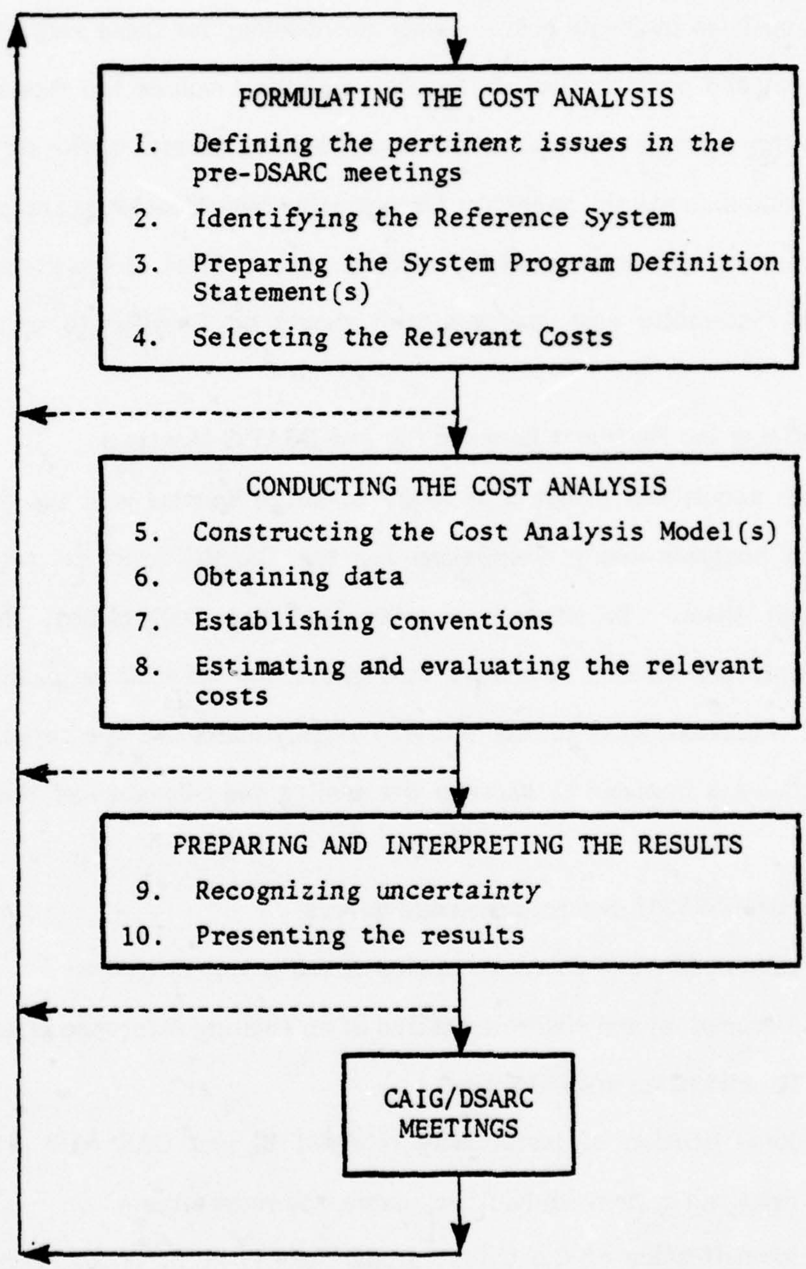
[3]See Appendix B for selected references on systems and cost analysis.

FIGURE 2. BASIC COST ANALYSIS METHODOLOGY



- Specification of content and ground rules for the cost evaluation and its presentation, including determination of all relevant variable costs to be included
- Specification of significant trade-off issues to be quantified and presented

2. Identifying the Reference System

To provide the required contemporary baseline against which to compare the costs of a proposed aircraft, a reference system must be identified. A reference system is an existing operational aircraft with a mission similar or analogous to that of the proposed aircraft. Usually, the aircraft being replaced is the reference system, unless another exists that provides a better point of reference for the cost analysis. The proponent of the new system and the Chairman of the CAIG should jointly select the reference system prior to Milestone I.

3. Preparing the System Program Definition Statement (SPDS)

A prerequisite to the development of useful SI and O&S cost estimates for any new defense system is a detailed definition of the weapon system program. The SPDS satisfies this need by

- Reflecting how the Military Department will use and support the weapon system(s)
- Supplying the essential assumptions and information for the cost estimates submitted
- Providing a set of historical data on the evolution of weapon system design, and the corresponding SI and O&S cost estimates from the beginning to the completion of the DSARC process
- Establishing a basis for critical review of mission requirements and how well the proposed system design and support concept will satisfy them
- Highlighting the design areas with high technological risks and cost uncertainty

For aircraft, the SPDS includes descriptions of missions, characteristics, and manning; and maintenance, support, and acquisition policies. The SPDS effectively augments the DCP by providing additional basic assumptions for the cost analysis. A basic outline of a SPDS for aircraft systems is presented in Table 2. The SPDS can also reference selected information in the backup material that documents the cost estimates.

The substance and detail of the SPDS depend on the phase of the acquisition program, and must be adjusted to O&S issues. At each pre-DSARC meeting, the specific content of the SPDS should be reviewed to ensure its responsiveness to the pending DSARC milestone. The SPDS for Milestone I will generally be less extensive than for subsequent DSARC Milestones. As the acquisition program progresses, however, the SPDS must be expanded to reflect progressive refinement of the aircraft design and support plans. Detailed analysis below the initial system or top-level cost estimates will be required, for example. The SPDS will then have to furnish such information as a detailed O&S scenario, to allow proper interpretation of the cost estimates.

The SPDS is a dynamic document—it changes as many initial expectations about design and support change during the acquisition program. Changes to the SPDS must therefore be made explicit. The initial SPDS, presented at Milestone I, should be retained as a baseline, and the revised SPDS should be annotated at subsequent DSARC reviews to identify changes from that baseline. The DSARC would thereby be informed that a premise of the initial O&S cost estimate had been changed, which would be likely to affect the estimate itself; and that they would therefore have to determine if the impact of such a change was significant.

4. Selecting the Relevant Costs

A cost element structure (CES) establishes a standard, multi-Service vocabulary for identifying and classifying the variable costs relevant to a weapon system program. The cost categories that make up the first and second echelons of the

TABLE 2. BASIC OUTLINE OF A SYSTEM PROGRAM DEFINITION STATEMENT FOR AIRCRAFT SYSTEMS

A. MISSION PROFILE
   1. Primary
   2. Secondary

B. AIRCRAFT CHARACTERISTICS
   1. Performance characteristics
   2. Physical characteristics
   3. Expected operational life
   4. Crew requirements

C. ACQUISITION PROGRAM
   1. Design-to-cost goal
   2. Number of Aircraft
      a. Deployed
      b. Training
      c. Pipeline
      d. Attrition
   3. Production/Deployment schedule
   4. Contract commitments on support cost control
   5. Special considerations for multi-national application

D. DEPLOYMENT
   1. Peacetime
      a. Number of CONUS/overseas bases
      b. Number and types of deployable units per base
      c. Number of aircraft per Training/Deployed Units
      d. Flying program (Training/Deployed Units)
   2. Contingency/Wartime Capability
      a. Number of CONUS/Overseas bases
      b. Number and type of deployable units per base
      c. Number of aircraft per Training/Deployed Units

D. DEPLOYMENT (Continued)
      d. Flying program (Training/Deployed Units)

E. SUPPORT CONCEPT
   1. Initial Support
      a. Organization (Note: For Navy and Marine Aircraft indicate land and carrier plans.)
      b. Location of initial operational unit(s)
      c. Use of contractor support
      d. Parts supply
      e. Initial training
   2. Mature System Support - For Each Echelon, Generally Described
      a. Organization (Note: For Navy and Marine Aircraft indicate land and carrier plans.)
      b. Functions performed
      c. Method of performance
      d. Skill requirements
      e. Support equipment requirements
      f. Workload

F. LOGISTICS GOALS
   1. Weapon System Goals
      a. Serial reliability
      b. Aircraft mean time to repair
      c. Operational ready rate
      d. Number of organizational and intermediate maintenance personnel per unit
   2. Subsystem Goals
      a. Engines
      b. Avionics
   3. Component Goals
      a. Radar
      b. Inertial Navigation System

recommended CES were shown in Table 1. The complete aircraft CES is discussed in Section IV, and the cost element definitions are given in Appendix A.

At step four of the cost analysis, the CES is applied to the acquisition program under consideration. A check is required to determine if all the relevant variable costs are represented and defined in a manner compatible with the cost analysis. Deviations from the recommended CES must be approved by the CAIG prior to use in the analysis for the DSARC.

5. Constructing the Cost Analysis Model

Specific models or techniques for calculating SI and O&S costs are not prescribed in these guidelines. There are several acceptable ways of generating SI and O&S cost estimates, and no one approach is best for all situations. In general, the context of the problem and cost analysis considerations determine the estimating process. Context includes the phase of the acquisition program, the decisions to be made, and the accuracy and resolution required in the estimate. The cost analysis considerations are the resources available for the task: time, data, methodology and manpower. A point of reference for the total cost estimate should be provided, along with visibility of key SI and O&S cost driver subsystems and policies, and an assessment of actions to reduce their impact.

The following criteria are useful for comparing and selecting cost-estimating models:

- Decisions involving trade-offs must use techniques that emphasize cost differences between alternatives; affordability estimates used for budget impact analysis may use macro techniques that emphasize a system-level perspective.
- For trade-off or program decisions, the cost-estimating technique must provide the accuracy required to distinguish the relative cost consequences of the alternatives. Such accuracy is a function of the design maturity of

the system or subsystem, the cost consequences of the decision, and the data and time available for making the decision. The amount of detail and the expected degree of accuracy of cost estimates ought to be reviewed explicitly in the pre-DSARC meetings.

- The estimating techniques must reflect the SI and O&S costs as a function of the aircraft's characteristics, operating profile, and program level considerations. Such considerations come into play, for instance, if alternative aircraft programs assume different numbers of aircraft to perform a given mission.
- The cost models must provide subsystem visibility by associating relevant costs with subsystems, and must be sensitive to specific subsystem characteristics and differences between alternatives.
- The cost-estimating model should, where feasible, be the same when comparing alternatives at similar stages of development. This is to ensure that differences between cost estimates of alternatives result from differences inherent in the alternatives, and not from differences in the cost-estimating approaches. When the cost-estimating approach is changed, information about the ensuing cost differences must be provided. However, when comparing conceptual systems with prototype systems or operational systems, the use of different cost-estimating approaches is justified.

6. Obtaining Data

Data are facts or assumptions about an aircraft's characteristics, the way it is operated and supported, and the costs or essential resources (i.e., fuel, manpower, spare parts, etc.) associated with it. The SPDS, combined with the DCP, is one source of data essential to the preparation of an SI and O&S cost estimate.

For these guidelines, data about both proposed and existing aircraft are needed. The proponent Military Department and the participating contractors are the principal data

sources for proposed aircraft. For existing aircraft, the using Military Department is the principal data source. Much of the data required for SI and O&S cost analysis is currently abstracted (in reports, or as planning and cost factors or rates) on an on-going basis, or will soon be available from products such as VAMOSC. These data will provide a basis for both the estimation of SI and O&S costs, and an assessment of the most costly subsystems and elements. Of particular interest are data that could be used to establish cost-reduction targets in design and support concepts. When there is an insufficient quantity of the desired data, its effect on the cost analysis and its results should be documented.

7. Establishing Conventions

Conventions for consistency in cost-estimating are presented below. They should be followed in all aircraft cost analyses for the DSARC, unless the CAIG Chairman and the Military Department representatives agree beforehand that a deviation would better serve the need for clarity. Any such deviations must be documented.

a. The Normative Approach to Cost-Estimating

These recommended guidelines focus on the relevant variable costs that should be incurred by a specific weapon system under the O&S conditions specified in the SPDS; they are not designed to estimate future budget expenditures directly. The difference is important. An estimate of actual expenditures presumes the ability to predict how institutions that control resource allocation and expenditures will behave. The normative approach used here attempts only to estimate what the future variable resource requirements should be, given certain assumptions about the characteristics of the aircraft, the tactical doctrine for deployment, the support policies, the intensity of operations, and so on.

The normative approach requires more than a projection of historical cost trends. The cost-estimating model must provide a logical link between the assumptions about the aircraft and the O&S conditions in the SPDS, and the resulting cost estimate. These cause-effect relationships are crucial. If the SPDS is changed, either the cost estimate must change, or the lack of change must be explained.

The normative approach applies to an existing aircraft when used as a reference system, as well as to alternatives for an acquisition program. The assumptions and cost-estimating methods for both the reference and proposed systems should be as similar as possible. Differences in O&S conditions (e.g., level of support, operating intensity, manning policies, etc.), must not obscure differences in aircraft characteristics affecting O&S resource needs.

b. Use of Constant Dollars

Future costs should be estimated in constant budget-year dollars of the fiscal year following the calendar year of the cost estimate. For example, if an SI and O&S cost estimate is made during calendar year 1976, then the cost estimate should be presented in fiscal year 1977 constant dollars. Adjustments for discounting and/or inflation can be presented in a separate analysis, when agreed upon in a pre-DSARC meeting.

c. Mature System Assumptions

The O&S characteristics of a weapon system change throughout its lifetime. As the aircraft matures, O&S requirements should approach a level more indicative of its design characteristics than was the case earlier. When estimating typical annual O&S costs (i.e., a snapshot of one year's O&S costs), a mature aircraft should be assumed. The characteristics of the mature system are those most likely to occur, and they might not always be the same as the design goals.

When developing a time-phased estimate, the expected rate of maturity must be considered, as well as the rate at which new aircraft will be added to the fleet. Different rates of maturity are particularly significant when comparing alternatives that differ markedly in their use of common subsystems, in the efforts devoted to finding and correcting design or support weaknesses, in the support strategies for the early years in the systems' lives, and in the rates at which operating experience is gained.

d. Personnel Costs

Military and civilian personnel costs are the largest component of aircraft O&S costs. The treatment of these personnel costs is therefore central to the

DSARC decision process. When conducting O&S cost analyses for DSARC/CAIG review, the Military Departments will use the military and civilian personnel pay and allowances rates published in DoD's Five Year Defense Plan (FYDP) for estimating the costs of manpower (retirement costs are excluded). For example, if the analysis is to be done in constant FY 77 dollars, the January FYDP pay rates will be used.

In addition to the above standard personnel cost perspective, there are times when the use of marginal economic costs of military and civilian personnel are relevant to the DSARC/CAIG review. Examples are selected capital-labor trades and organic versus contractor repair comparisons, in which retirement cost considerations can be relevant. In those cases, and in response to a specific request by the CAIG, the Military Departments will submit separate cost analyses reflecting the pertinent personnel economic costs.

e. Capital Investment Lead Time Considerations

Requirements for support investment items (e.g., support equipment, facilities, reparable spares) are determined by the mission scenario, buildup schedule, workload, etc. When these requirements are interpreted in terms of budget appropriations, explicit procurement lead time allowances must be incorporated.

For the constant year dollar estimates called for in these guidelines, the aggregated sum of the support investments will be the same, regardless of whether or not lead time allowances are incorporated. Presentations of time-phased costs, even in constant year dollars, are nevertheless sensitive to lead time assumptions. The time-phased cost estimates should be reflected for those years when the appropriation would most likely be made.

8. Estimating and Evaluating Relevant Costs

The analysis of O&S costs during the DSARC review is vital to the selection, improvement, and control of design, development, and support concepts for the proposed weapon system. The purposes of the O&S cost analyses recommended here are: first, to explore and quantify the relative advantages of different concepts (for example, the comparison of new and old systems, alternative support policies, etc.), and, second, to

provide a means of estimating the impact of O&S costs upon affordability and force structure planning (e.g., the F&FP, POM, FYDP and EPA process). A fundamental consideration in the DSARC process is that the proposed aircraft system satisfy its mission requirements at the lowest O&S costs commensurate with overall minimization of LCC. DoD policy requires analysis of outyear costs during development, design, and procurement, with the objective of reducing future allocations for such operation and support.

The cost analysis and its formulation (e.g., parametrics, scaling, etc.), needed for a specific program review will depend on the type of aircraft, the stage of the acquisition program, and the issues concerning the DSARC. Several types of analysis are frequently required.

a. Cost Analysis

Cost analysis is used to determine the full set of relevant variable costs and how they compare between the reference system and program alternatives. The analysis places the cost estimate(s) in perspective, and explains why the proposed aircraft is expected to require the O&S resources estimated.

b. Trade-off Analyses

Trade-off analyses are used to explore cause-effect relationships between costs and changes in design or support concepts. A special kind of trade-off analysis, maintenance and support requirements (MSR) analysis, is recommended here. MSR analyses are directed towards such issues as the effect of design characteristics and support policies on maintenance costs. They are frequently significant in the selection of subsystems, evaluation of support policies, and establishment of O&S goals. Section V of this report is devoted to MSR analysis and its relationship to total system O&S cost analysis.

c. Sensitivity Analysis

Sensitivity analysis is used to identify aspects of the acquisition program

important in controlling O&S costs. It can influence such activities as establishing O&S goals and determining test and evaluation requirements.

A special case of sensitivity analysis is the assessment of demand-driven uncertainty. Such analyses explore the impact on O&S costs of varying the assumptions of a cost estimate, the characteristics of the aircraft, or the support policies, over a range of likely values. Technical uncertainties are often analyzed in this manner.

d. Statistical and Budget Uncertainty Analysis

Statistical and budget uncertainty analysis is used to interpret and present the uncertainties inherent in the particular cost model and its application (technical, demand, statistical and budget assumptions), and their meaning for the program budget.

e. Trend Analysis

Trend analysis is used to compare the proposed aircraft with its historical counterparts. Of particular interest are: comparisons of hardware subsystems, design characteristics, and support policies and procedures that have historically dominated O&S costs; extent of departure from historical practices; and actions planned to reduce the consumption of O&S resources. Historical trends for the aircraft class (including the reference system) can be used to establish O&S bounds and goals for selected characteristics of the proposed system. For each significant cost element, the principal cost drivers can be classified by:

- Hardware subsystems (e.g., frame, propulsion, avionics, etc.)
- Design characteristics of the subsystems (e.g., limited modularity, poor fault diagnosis accuracy, etc.)
- Support policy and procedures (e.g., level of repair decision, contractor support, etc.)

Each historical cost driver thus identified should be accompanied by an explanation of whether or not the problem is expected to occur in the proposed system, and the actions necessary to control and/or reduce the future requirements for the

proposed aircraft. The trend and cost minimization analysis can then be used to establish bounds within which the characteristics of the proposed system would be considered normal, and to establish goals for reduction of O&S requirements.

9. Recognizing Uncertainty

Estimates of future aircraft O&S costs are beset by uncertainties from many sources:

- Quality of data available
- Methods used to estimate costs
- Decisions yet to be made about design or use
- Changes in the scope of the acquisition program (e.g., quantities, costs, or schedule)
- Technical or technological problems encountered during development
- Operating and Support environment
- Aircraft characteristics that will become evident only after years of operational experience

No O&S cost analysis can consider all these uncertainties. Nor does it need to. Most variables in an O&S cost estimate can be treated deterministically, as long as assumptions about their values are reasonable and explicit. For example, the quantity of aircraft to be operated is a variable with a significant impact on O&S cost. Yet, unless quantity is the issue to be decided, the quantity for the O&S cost estimate can reasonably be assumed to be the same as that stated in the DCP and SPDS. Other areas where reasonable assumptions can be treated deterministically or as a given are: mission scenario, deployment plans, and flying program. Such assumptions must always be stated explicitly in the SPDS, of course, and remain consistent (though not necessarily identical) across alternatives.

Certain aspects of uncertainty must be communicated to the DSARC under all circumstances. First, some uncertainty is inevitably associated with the O&S cost

estimate, even though many of the variables might be treated deterministically, and the results presented as point estimates. Several of the illustrative formats in Section VII permit the presentation of a range for the estimate that would show the magnitude of the uncertainty. When a range is used, the documentation should include an explanation of the method used to establish the bounds of the range. References in Appendix B discuss other techniques of quantifying uncertainty in cost estimates. When quantification of uncertainty proves impractical, a qualitative assessment of the estimate must be made.

Second, the DSARC must be apprised of the major risks of the acquisition program, their likely impact on O&S costs, and feasible alternatives for reducing them. For example, an O&S cost estimate is frequently sensitive to the goals established for reliability and maintainability of the aircraft and selected critical subsystems. If the fulfillment of these goals appears doubtful during the development phase, the cost impact of poorer reliability and maintainability should be investigated, and, if significant, presented to the DSARC.

Third, the DSARC needs to know the effect of uncertainty upon the relative merits of alternatives. Is there so much uncertainty in the estimates that the O&S cost differences between alternatives are masked? Do other reasonable assumptions about some variables change the order of preference? If the answer to either question is "yes," then a specific sensitivity analysis of the key parameters is required, and the results should be discussed with the DSARC.

10. Presenting the Results

The goals for cost presentations are twofold: to present timely and relevant results, and to place them in perspective. A discussion of the presentation of the relevant variable costs for aircraft systems is given in Section VI. Suggested formats are shown in Section VII.

Different types of presentation may be required to highlight the cost consequences of various issues before the DSARC, such as subsystem trade-offs,

maintenance and support analysis, or manning requirements. The presentation requirements described in Section VI should be augmented with selective displays of the results of cost analyses specifically requested by the DSARC. There must be a logical consistency underlying all the presentations throughout the DSARC process to permit tracking of the outputs and trend data generated in the cost analysis between the decision milestones.

IV. THE COST ELEMENT STRUCTURE

A. INTRODUCTION

This standard cost element structure (CES) defines the O&S functions and resource categories affected by the acquisition program. It promotes consistency in the computation and display of costs, and helps the DSARC concentrate upon those decisions having the greatest impact on future O&S resource needs.

The CES for aircraft SI and O&S costs is shown in Table 3. Definitions are given in Appendix A. Elements for investments to facilitate operating and support are included. Most analyses that address the O&S cost impact of alternatives must also address their impact on these support investment costs. With the exception of cost element 202.7 (War Reserve), the support investment cost elements are consistent with those reported in the Selected Acquisition Report (see DoDI 7000.3), and the Work Breakdown Structures for Defense Materiel Items (see DoDD 5010.20).

The structure is designed specifically for the DSARC's decision needs when reviewing aircraft acquisition programs, and not for accounting purposes. However, the relevant variable costs defined yield useful information for force structure or budget analysis.

B. SIGNIFICANT COST ELEMENTS

Not all cost elements require or deserve the same attention when developing cost estimates for a new aircraft. The greatest analytic effort should be devoted to those accounting for a substantial part of the total SI and O&S costs, which can be affected by acquisition program decisions or assist in distinguishing between alternatives. In the Support Investment category, the elements normally deserving the greatest attention are: 202.1 (Support Equipment), 202.4 (Initial Spares and Repair Parts), and 202.5 (Spare Engines). In the Operating and Support category, the significant cost elements are

TABLE 3. AIRCRAFT COST ELEMENT STRUCTURE

100 Research and Development

200 Investment

- 201 System Investment
- 202 Support Investment
  - 202.1 Support Equipment
  - 202.2 Training Equipment and Services
  - 202.3 Documentation
  - 202.4 Initial Spares and Repair Parts
  - 202.5 Spare Engines
  - 202.6 Facilities (Non-production)
  - 202.7 War Reserve Materiel
    - 202.7.1 Spares
    - 202.7.2 Repair Parts
    - 202.7.3 Munitions
    - 202.7.4 Missiles
    - 202.7.5 Sonobuoys
    - 202.7.6 Tanks, Racks, Adapters & Pylons

300 Operating and Support

- 301 Deployed Unit Operations
  - 301.1 Aircrews
  - 301.2 Command Staff
  - 301.3 POL
  - 301.4 Security
  - 301.5 Other Deployed Manpower
  - 301.6 Personnel Support
- 302 Below Depot Maintenance
  - 302.1 Aircraft Maintenance Manpower
  - 302.2 Ordnance Maintenance Manpower
  - 302.3 Maintenance Materiel
  - 302.4 Personnel Support

300 Operations and Support (Continued)

- 303 Installations Support
  - 303.1 Base Operating Support
  - 303.2 Real Property Maintenance
  - 303.5 Personnel Support
- 304 Depot Maintenance
  - 304.1 Manpower
  - 304.2 Materiel
- 305 Depot Supply
  - 305.1 Materiel Distribution
  - 305.2 Materiel Management
  - 305.3 Technical Support
- 306 Second Destination Transportation
- 307 Personnel Support and Training
  - 307.1 Individual Training
  - 307.2 Health Care
  - 307.3 Personnel Activities
  - 307.4 Personnel Support
- 308 Sustaining Investments
  - 308.1 Replenishment Spares
  - 308.2 Modifications
  - 308.3 Replenishment Ground Support Equipment
  - 308.4 Training Ordnance
    - 308.4.1 Munitions
    - 308.4.2 Missiles

normally: 301.1 (Aircrews), 301.3 (Aviation POL), 302 (Below Depot Maintenance), 304 (Depot Maintenance), and 308.1 (Replenishment Spares).

Other cost elements not pertinent to distinguishing between alternatives can usually be addressed in a straightforward manner with planning factors. For example, cost element 303 (Installations Support) is included in the structure to provide the DSARC with an appreciation of the full variable O&S costs of operating the aircraft in a tactical unit. However, the magnitude of Installations Support costs is usually more a function of the Military Department's doctrine for organization and operation than a function of aircraft characteristics. The same guidance applies to 307.2 (Health Care). For the non-significant cost elements, planning factors should be used, unless alternatives need to be compared in greater detail.

C. COST ESTIMATE COVERAGE

The CES leaves open the choice of whether the cost estimate should be for a single aircraft, a deployable unit (e.g., squadron or company), or the total fleet. In most cases, the choice will be the deployable unit or fleet. Decisions on affordability or budget impact require visibility of total fleet costs, time-phased over the expected life of the weapon system. Decisions between design or support alternatives require visibility of their relative impact on the O&S costs of a typical deployable unit.

Table 4 presents guidance for selecting and interpreting the cost elements to be included in SI and O&S cost estimates for a single aircraft, a deployable unit, or a fleet of aircraft. As a matter of convention, single aircraft costs will include only those costs likely to be incurred when adding one more aircraft to a deployable unit. Deployable unit costs will include all variable costs for operating and support of a typical, tactical organization equipped with the proposed aircraft. The typical unit, either real or hypothetical, shall be one that best represents the O&S cost impact of tactical deployment of the aircraft. Fleet costs include all relevant variable costs that are attributable to the weapon system by the cost structure in Table 3.

TABLE 4. GUIDE TO COST ELEMENT ALLOCATION AND SUMMARIES

SI and O&S Cost Elements	Single Aircraft	Deployable Unit	Fleet
202 Support Investment			
202.1 Support Equipment		X*	X
202.2 Training Equipment and Services			X
202.3 Documentation			X
202.4 Initial Spares and Repair Parts	X	X	X
202.5 Spare Engines	X	X	X
202.6 Facilities (Non-Production)		X*	X
202.7 War Reserve Materiel			X
300 Operating and Support			
301 Deployed Unit Operations	X	X	X
302 Below Depot Maintenance	X	X	X
303 Installation Support		X	X
304 Depot Maintenance	X	X	X
305 Depot Supply			X
306 Second Destination Transportation		X	X
307 Personnel Support and Training		X	X
308 Sustaining Investments		X	X

*The costs of Support Equipment and Facilities required for depot or fleet support are not to be allocated to deployable units.

The O&S cost estimates should be based on expected peacetime deployments and activities, unless specified otherwise in the pre-DSARC meetings. The scenario that best reflects the expected utilization and support of the proposed aircraft and generates the most likely SI and O&S resource requirements should be used, and described in the SPDS.

D. COSTS NOT INCLUDED IN THE SI AND O&S COST ANALYSIS

The underlying principle of the cost analyses recommended in these guidelines is the inclusion of all variable SI and O&S costs associated with the proposed weapon system that are relevant to the decisions made during the DSARC process. Some costs are consequently excluded.

1. Research and Development

This category covers all RDT&E costs, including: research costs incurred in developing the production design of the new aircraft, aircraft components and support equipment; and costs associated with the development and test of the new system (including prototype and test vehicle costs) through the end of the acquisition process.

2. System Investment

This category includes all system flyaway costs and investment costs (except those noted under cost category 202—Support Investment).

3. Base Headquarters and Services

This category includes costs of personnel and materiel primarily dependent on the existence of the base; they are considered to be base-fixed costs, independent of the type of aircraft unit located there. Base-fixed costs pertain to:

- Maintenance and protection of base facilities, such as buildings, road construction and repair, police and fire protection, trash and sewage disposal and utility services
- Maintenance of base living conditions (commissaries, exchanges, religious activities, and sports and entertainment facilities)
- Supervision of the above activities

4. Central Support Overhead

The pay of personnel assigned to headquarters organizations that provide administrative guidance and oversee the operation of depot maintenance, supply depots, recruiting, aircrew and technical training activities, and the cost of upkeep of these headquarters facilities, including personnel support costs, are excluded from the O&S cost estimate. For example, these headquarters activities include Army Materiel Development and Readiness Command, Air Force Logistics Command, Naval Materiel Command, and fixed overhead at the Service depot repair facilities.

5. Command Structure Overhead

The pay of personnel assigned to operating headquarters and staffs at and above the level of numbered Army, Air Force Air Division, Navy Air Wing and Fleet Marine Force, and the cost of upkeep of these headquarters facilities, including personnel support costs, are excluded from the O&S cost estimate. Collectively, these headquarters directly supervise the operation of the combat units and provide overall policy formulation and administration of the entire Service.

6. Selected Non-Service Appropriated Funds

The cost of programs, such as family housing, not directly identifiable with a specific Service appropriation, is excluded from the O&S cost estimate.

V. MAINTENANCE SUPPORT REQUIREMENTS ANALYSIS

A. INTRODUCTION

The subset of cost elements that represent the cost of weapon system maintenance and support requirements (MSR) is especially important. MSRs are particularly relevant to design and policy evaluations, and to O&S cost estimates. The set of significant MSR-related cost elements typically includes:

202.1	-	Support Equipment
202.4	-	Initial Spares and Repair Parts
202.5	-	Spare Engines
302.1 & 2	-	Below Depot Maintenance
304.1 & 2	-	Depot Maintenance
302.1	-	Replenishment Spares

Any other cost elements significantly affected by the MSR should be incorporated into the analysis. Such elements as transportation or supply management may, under certain circumstances, be relevant to a trade-off analysis.

B. OBJECTIVES

1. To state clearly the rationale for estimating the MSR-related cost elements. In other words, to explain how the estimates for the MSR-related cost weapon system elements are derived as a function of its logistics characteristics (e.g., reliability maintainability, etc.), and support policy.

2. To structure selected trade-offs between system design and policy alternatives and O&S costs, and to link the results functionally to system-level O&S cost impacts. This analysis is geared to such questions as: "For a given capability, what alternative system MSRs will provide opportunities to reduce O&S costs, and by how much?" and "What are the O&S cost implications of using existing components in the proposed weapon instead of developing a new and unique component?"

3. To describe the link between demand-related maintenance and support activities and O&S requirements for the total system.

At a minimum, the MSR analyses should:

- Identify significant MSR-related cost elements
- Functionally incorporate reliability and maintainability characteristics, and support policies relevant to the weapon system
- Utilize a pertinent measure of weapon system or subsystem capability (e.g., availability rate) in comparing and trading off alternatives
- Interpret the output of the MSR analysis in terms of expected impact on weapon system O&S costs
- Be adequately documented (the documentation is to be available to the DSARC)

C. CATEGORIES OF MSRs

Aircraft MSRs can be separated into two categories: system-driven and policy-driven. System-driven requirements can be characterized as inherent or design requirements. Policy-driven requirements arise from the user Military Department's policy for deployment surge activity allowance, personnel skills, training, and so on. Hardware designers can affect system-driven requirements directly, but influence policy-driven requirements only indirectly. Policy-driven requirements are basically controlled by the Military Departments. Both categories of aircraft MSRs must be taken into account before realistic estimates of O&S costs and their impact can be made.

1. Computation of System-Driven Requirements

The computation of MSRs explicitly involves reliability, maintainability and support policy-related variables. A number of different techniques will generally be potentially applicable at any one time. Selection of a model necessarily depends upon the situation, and, ultimately, upon the analyst's confidence in the chosen technique. Several criteria should be observed when selecting and applying a model for estimating MSRs.

a. System Perspective

MSR analysis of trade-offs concerning subsystems (propulsion, avionics, etc.), and components (inertial measurement system, radars, etc.) generally reflects a subset of the weapon system requirements. The critical task is to isolate the level of the MSR analysis, and to define the models, requirements, and input data consistently. The observed MSRs can thus be attributed to the system, component, or item of interest. Selection of the appropriate level of analysis should be based on the status of the system design and the pending O&S cost issues. An illustration of MSR levels of analysis, and their hierarchical relationships is given in Figure 3.

b. Relevance to DSARC Issue

The MSR analysis must fit the DSARC issue under investigation. If affordability is the issue, then the MSR analysis must deal with all the relevant weapon system MSRs for developing cost estimates. If, on the other hand, the issue is improvement of a given design, then a MSR trade-off model that can distinguish between the pertinent alternatives must be used.

c. Incorporation of the Right Variables

The MSR analysis should show functional relationships among the variables relevant to the decision. An expression for estimating the impact of a design change on spares investment in terms of weight and speed is not particularly useful, for example. Weight and speed are not pertinent to spares investment decisions. An appropriate model would explicitly relate reliability, maintainability, availability and support policy to the spares investment. The model must also be susceptible to modification, so as to deal only with the pertinent variables and allow the others to be ignored or factored as constants.

d. Satisfaction of DSARC Information Requirements

Output from the model should address the issues and alternatives directly. For example, if the impact of a design or policy change on organizational-level

FIGURE 3. TYPICAL MSR FUNCTIONAL ELEMENT STRUCTURE

LEVEL OF COST ANALYSIS DETAIL DEPENDS ON PROBLEM, SUBSYSTEMS, STATUS OF ACQUISITION PROGRAM

WORK UNIT CODE

AIRFRAME
- 11 Airframe
- 12 Cockpit & Fuse Compartment
- 13 Landing Gear
- 14 Flight Controls
- 24 Secondary Power
- 41 ECS
- 42 Electrical
- 44 Lighting
- 45 Hydraulics
- 47 Oxygen System
- 91 Emergency Equipment
- 97 Explosive Devices

PROPULSION
- 23 Engine

AVIONICS
- 51 Instruments
- 52 Autopilot
- 55 MAL ANAL, etc.
- 57 INT GUID, etc.
- 63 UHF Comm
- 65 IFF
- 71 Radio Nav
  - 71A INS
  - 71B Direction Finder
  - 71D ILS
  - 71D TACAN
    - 71DA Rec-XMTR
    - 71DB Antenna
    - 71DC Antenna
    - 71DD SW, Rad. Freq.
  - 71F Att. HD. REF.
- 74 Fire Control
- 75 Wpns Del
- 76 TEWS

LEVEL I (Subsystem)	LEVEL II (Components)	LEVEL II (Item - 3rd Level)	LEVEL IV (Item - 4th Level)

LEVELS OF MSR ANALYSIS

manpower requirements is in question, that specific impact should be an output, and not be buried in a total manpower estimate. The estimate of such an impact should be realistic and sufficiently documented. A related issue is how well the model output identifies the degree of certainty or uncertainty inherent in the analysis and input data. As more information is obtained, the associated growth in certainty should be explicitly reflected.

e. Satisfaction of Similarity Assumptions

In order to make projections, many models depend heavily upon assumptions requiring explicit similarity between old and new items. It is vital to recognize whether or not such assumptions can be satisfied. Analogy, for example, requires a direct, obvious relationship between one or more historical data points and a future application. If such a relationship does not exist, then analogy is inappropriate.

f. Operational Feasibility

Even if all the above criteria are satisfied, the use of certain models may not be practical. Either the constraints must be relaxed, or different models used. Three critical dimensions of operational feasibility are data, time, and level of effort. Some detailed engineering analyses and simulation models require an extensively detailed and validated data base. A great deal of time (e.g., several months) and exclusive use of skilled personnel and computer resources may also be needed.

2. Adjustment for Policy-Driven Requirements

Distinguishing between design-inherent requirements for maintenance resources and for policy-related personnel resources offers useful insight into the drivers of weapon system O&S costs. MSRs calculated at subsystem or lower levels of indenture are indicative of demand-related and design-inherent requirements. The approach generally concentrates on direct maintenance and support requirements generated by the weapon system and/or its parts. Consequently, these MSR values are usually less than the "real-life" MSR for the weapon.

To assess a reliability, maintainability or support policy impact properly, the "basic" MSR model output must be adjusted to reflect the most likely value that would occur. The process can be understood as linking the basic MSR model output with other system-level and management policy requirements to generate a system-level O&S cost estimate. These additional requirements reflect the system's demands for: servicing; maintenance of support equipment, training devices, and other system hardware; and overhauls and scheduled maintenance not directly related to reliability. In particular, the design-related maintenance manpower requirements at the organizational and intermediate levels (e.g., below depot maintenance), will be lower than the actual manning levels, which will reflect policy and training considerations. Such considerations include the necessity to man to accommodate an organizational deployment or a surge in utilization. Military personnel assignment policies and limited ability to cross-train maintenance personnel in multiple skills also necessitate the calculation of whole quantities and associated costs. Early in the DSARC process, a linkage between the MSR and O&S calculations should be established that accounts for policy impacts, yet does not mask the effects of the reliability and maintainability characteristics of the proposed system.

D. INTERPRETATION

What system-level O&S cost impacts can be inferred from an MSR analysis, particularly an MSR trade-off analysis? The issue is complex, and the inferences must be carefully documented as part of the back-up material for the CAIG.

When MSR results are used to estimate certain cost elements, and when those results are used directly as one of the inputs to the system-level O&S cost estimate, changes in the MSR results can be related directly to an O&S cost impact. This interpretation is straightforward.

Generally, however, the interpretation of MSR results is more difficult. The initial, or available, system O&S cost estimate is usually derived from an entirely separate analysis, which could have utilized comptroller data, parametric relationships, scaling,

cost factors, etc. These "top-level" analyses may not identify estimates for MSR-related cost elements separately. It may therefore be inappropriate to say that a change in the estimate for a selected cost element based on an MSR trade-off analysis will in fact be the impact on future system-level O&S cost. The two numbers are the products of two different models or analyses. Still, they must be based on the same SPDS, which allows them to be used in the context of the same weapon system.

The most difficult case is estimating an O&S cost impact of an MSR trade analysis applied at a below-system-level of assembly. The MSR analysis necessarily reflects the values for the change to that level only. Even when the results are fully adjusted for policy requirements, they are still representative only of requirements at that particular level. In this case, the interpretation of the MSR trade analysis must take into account the dual adjustments for the system hierarchy and the separate cost estimates. The inferred O&S cost impact attributable to the MSR trade-off must be explicitly qualified and clearly documented.

VI. PRESENTATION REQUIREMENTS, FORMATS AND DOCUMENTATION

A. INTRODUCTION

This section describes the SI and O&S cost information needed by the DSARC for review of an aircraft acquisition program. The presentation requirements described below are guidance; they represent expected information needs. They in no way limit the use of imagination and good judgment in presenting additional cost information relevant to acquisition program decisions.

B. TAILORING THE ANALYSIS AND PRESENTATION

The presentation of SI and O&S cost analyses must be tailored to the phase of the acquisition program and the cost issues involved. As a program progresses from concept formulation through each DSARC decision milestone, the issues change, and both the uncertainties involved in SI and O&S cost estimation and the opportunities to affect those costs diminish. Consequently, the nature of the DSARC decisions and the related cost analyses will change as the design progresses.

Prior to each DSARC review, the proponent of the program and the chairman of the CAIG should agree upon the specific composition of, and ground rules for, cost presentations. Depending on the phase of the program and the specific issues involved, the cost analysis might address (singly or collectively) alternative weapon systems, subsystems, or support plans. Interest frequently will focus on the sensitivity of certain costs to the goals established for mission performance and support of the aircraft, also.

C. OBJECTIVES OF THE COST ANALYSIS

Although each cost analysis and its format must be tailored to the decisions at hand, it should always:

- Define each alternative
- Identify differences between alternatives
- Show cost impacts of the differences, taking uncertainty into account

- Explain the rationale of the cost analysis (assumptions, limitations, methods and data) and note any deviations from the guidelines
- Relate the results to decisions being considered by the DSARC

D. COST SUMMARY REQUIREMENTS

The results of the cost analysis should be presented in summary form to direct the attention of the DSARC principals and other senior DoD officials to the SI and O&S cost impacts of the decisions they are considering. The summary is a concise, results-oriented presentation of the key points of the analysis including the following nine items.

1. Time-Phased SI and O&S Cost Estimates for the Proposed System by Cost Element

- Format: Table
- Rows: SI and O&S costs of the aircraft fleet
- Columns: Fiscal years covering the point from which appropriations for support investment items are made, and the operational life of the aircraft
- Entries:
  a. *Constant* year dollars, as per the convention noted in III.C.7.b.
  b. Total number of aircraft, broken out by active, reserve and training units by fiscal year
  c. Uncertainty range indicated for all column cost totals

2. Time-Phased SI and O&S Cost Estimates for the Proposed System by Appropriation

- Format: Table
- Rows: Major or Prime Appropriations, as defined in DOD 7110-1-M, and applicable to the cost analysis
- Columns: Fiscal years covering the point from which appropriations for support investment items are made, and the operational life of the aircraft
- Entries:
  a. Constant year dollars, as per the convention noted in III.C.7.b. (Note: The sum of this matrix must equal the total in the above time-phased cost matrix. Appropriate adjustments for personnel budget costs versus economic costs, and considerations for the lead time allowances for capital investments as well (e.g., support equipment, spares, etc.), must be documented.)
  b. Uncertainty range indicated for all column cost totals

3. Total SI and O&S Cost for the Proposed System by Selected Subsystem

- Format: Table
- Rows: Significant cost elements from Table 3
- Columns: Subsystems defined in DoDD 5010.20 or MIL STD 881, or others of specific interest to the DSARC
- Entries:
  a. Constant year dollars accumulated over the operational life of the weapon system.
  b. Uncertainty range indicated for all column cost totals

4. Comparison of the Annual O&S Costs of the Proposed System at Maturity with the O&S Costs of the Reference System, and the Estimate by the Independent Cost Analysis Group

- Format: Table
- Rows: O&S cost elements listed in Table 3
- Columns: Reference System, Proposed—Baseline, Proposed—Current, and Proposed—Independent (Note: The baseline and current estimates are the same at Milestone I; at subsequent presentations the baseline becomes the Milestone I estimate, and the current estimate is the latest estimate.)
- Entries:
  a. Constant year dollars (as per the convention noted in III.C.7.b. for a deployable unit). (Note: Clearly indicate if the reference and proposed aircraft have different deployment concepts.)
  b. Uncertainty range indicated for all column cost totals (Note: The cost estimates for the reference system are normative costs; that is, the costs the system would most likely require if it were used to perform the mission under consideration. As part of the documentation for these cost estimates, the historical costs for the reference system must be identified in the backup material.)

5. Comparison of Life Cycle Support Investment Costs of the Proposed System with the SI Costs of the Reference System, and the Estimate by the Independent Cost Analysis Group

- Format: Table
- Rows: SI cost elements listed in Table 3
- Columns: Reference System, Proposed—Baseline, Proposed—Current, and Proposed—Independent (See Note on above item #4)
- Entries:
  a. Constant year dollars (as per the convention noted in III.C.7.b.) for an equivalent fleet size for both reference and proposed Aircraft
  b. Uncertainty range indicated for all column cost totals

6. Comparison of Historical Trends for the Aircraft Class and Goals of the Proposed System for Selected Significant Cost Elements

- Format: Graphical
- Ordinate: Units of the significant cost element (e.g., cost in dollars of below depot maintenance manpower, or the number of personnel for below depot maintenance manpower)
- Abscissa: Units of time (e.g., years)
- Plot:
  - a. Historical trend data for a deployable unit of the aircraft class
  - b. Historical data for the reference system deployable unit
  - c. Projected goals for the proposed system deployable unit at maturity

  (Note: Separate plots are required for each significant cost element of interest to the CAIG/DSARC)

7. Historical O&S Cost Drivers and Corrective Actions for the Proposed System

- Format: Table
- Rows: Selected Subsystems/Components/Activities Driving Costs
- Columns:
  - a. Percentage of aircraft maintenance costs
  - b. Major problem(s) contributing to maintenance costs
  - c. Cost reduction action planned for the proposed system
- Entries:
  - a. Numerical percentages (%)
  - b. Narrative descriptions of problems and actions

8. Maintenance and Support Requirements Analysis Results and Documentation

For each of the MSR-related cost elements, a documentation module must be submitted providing:

- Estimated value of the cost element
- Background for the MSR analysis
- Description of how the value of the cost element was derived—in particular, interpretation of the MSR analysis for O&S cost impacts
- Record (narrative and mathematical) of the expression used to derive the value of the cost element

- Description of the bounds within which the expression applies (pertinent assumptions must be discussed explicitly)
- Definition of each input variable
- Discussion of how individual values were derived (particularly reliability and maintainability measures)
- Record of the source(s) and references used in the determination of input variables

These descriptions can include tabular, mathematical, or graphical data relationships, reflecting cost as a function of pertinent physical, performance, and deployment data from the history of the weapon class or the reference system.

9. Sensitivity Analysis and Documentation

An analysis of the sensitivity of the projected costs to all the critical assumptions in the cost analysis is also required. The presentation may be graphical or tabular, and must cover the SI and O&S cost impacts of changes in the following SPDS categories:

- Performance characteristics/mission scenario
- Aircraft characteristics
- Deployment policy
- Acquisition policy
- Support policy
- Logistics goals

E. SELECTIVE COST ANALYSES AND PRESENTATIONS

Additional cost analyses and trade-off studies expressly for the weapon system under DSARC consideration will also be required. Results for each specific request must be presented in a manner consistent with the presentation and backup documentation called for in VI. D.

F. COST ANALYSIS BACKUP MATERIAL

Complete documentation of the required SI and O&S cost analysis should be submitted to the CAIG as backup material. Other relevant backup material should be made available to the CAIG upon request. The purpose of such material is to permit a detailed review of the assumptions, cost-estimating methods, data sources, and rationale of the analysis; it will therefore be organized for rapid examination. Each entry in the O&S cost presentation should be sufficiently documented for reproduction by a competent analyst, using the assumptions, methods and data included in the SPDS and backup material. The backup material should also explain the rationale of the cost estimate.

Backup material for the cost analysis ought to document the development of the following:

1. SPDS for the reference aircraft, the proposed aircraft, and any alternative under consideration

2. Total SI costs of the reference system, the proposed aircraft, and other alternatives considered (Using the same SPDS, show both the program office estimate and the independent estimate, and explain major differences.)

3. Annual O&S costs of the reference aircraft, the proposed aircraft, and alternatives (Using the same SPDS, show both the program office estimate and the independent estimate.)

4. Time-Phased SI and O&S costs for the proposed program and alternatives

5. Sensitivity of the SI and annual O&S costs to the aircraft characteristics, support policies, or cost-estimating assumptions that have the greatest influence on costs

6. O&S cost trend analysis of the subsystems, components, support activities or resource requirements that have historically accounted for the significant O&S costs of similar aircraft

7. Documentation of each cost element estimate, including:

   - Description of derivation

- Record (both narrative and mathematical) of the expression used to derive its value
- Description of the bounds within which the expression applies (pertinent assumptions must be noted explicitly)
- Definition of each input variable
- List of values assigned to input variables
- Discussion of derivation of individual values
- Record of source(s) and references used in determining input variables

VII. SELECTED ILLUSTRATIONS OF THE O&S COST ANALYSIS AND REVIEW PROCESS

A. INTRODUCTION

Sections I through VI of this report recommended principles and standards for preparation and presentation to the DSARC of estimates of O&S costs of aircraft systems. They describe the DSARC's expectations concerning an O&S cost analysis for a proposed aircraft acquisition program.

Section VII explains the nature of the O&S cost analysis process, the content of typical DSARC presentations, and the multi-Service applicability of the recommended cost element structure. Its principal messages are: tailor the O&S cost analysis to the acquisition program; clearly and concisely communicate relevant results to the DSARC; and place those results in perspective so that the DSARC understands the O&S cost impact of program decisions.

First, the importance of the pre-DSARC meetings in defining the context of the O&S cost analysis and adjusting it to current acquisition issues is re-emphasized. Second, some illustrations of various methods of presenting SI and O&S cost information to the DSARC are given. They include a SPDS, several approaches to presenting cost trend and goal information, and examples of SI and O&S cost estimates. The cost estimates are presented in formats demonstrating the use of the cost element structure introduced in Section IV, as well as such concepts as the reference aircraft, and the baseline, current, and independent estimates for the proposed aircraft. Several examples of related cost analysis products are provided to demonstrate logical differences among Military Departments, types of aircraft, or phases of the acquisition process.

The illustrations are hypothetical, though most are based on real issues and systems. They are descriptive rather than prescriptive. The cost analysis and its presentation must always be tailored to the issues under consideration, the stage of development of the weapon system, and the available data and methods of analysis.

This section concludes with several examples of micro-analysis. These types of analysis,--such as maintenance and support requirements analyses, sensitivity analyses, and trade-off studies,--frequently underlie many acquisition program decisions. They need be presented to the DSARC, however, only upon request, or when central to issues being discussed.

B. PRE-DSARC MEETING PREPARATION

While the basic theme and objectives of each DSARC are the same, the specific content and formulations of the SI and O&S cost estimates required will differ. Pre-meeting preparation is necessary to tailor the analysis to the particular need.

Well in advance (at least 60 days, as per DoDD 5000.26) of a scheduled DSARC meeting, the Chairman of the CAIG, OSD program monitors and the proponent of the aircraft acquisition program should agree upon substantive issues and minimum requirements for the cost analysis. Some basic topics and issues which require pre-meeting discussion and agreement are given in Table 5. Note the differences between the types of alternatives and issues addressed at Milestone I and at Milestone III. Early in the acquisition process, one of several different viable concepts that satisfy a specified mission requirement has to be chosen. Later in the acquisition process, after the range of alternative designs has been reduced, minor configuration changes, readiness of the system for production, and initial support plans are important. Of course, at any stage in the acquisition program, rescheduling, delay or termination may be considered as program alternatives.

C. SYSTEM PROGRAM DEFINITION STATEMENT (SPDS)

The SPDS is an extension of the DCP, and summarizes the characteristics of the aircraft, and the operating and support environment that generate SI and O&S resource requirements. In effect, the SPDS states the premises of the cost estimate and briefly describes the differences among the reference, proposed, and alternative systems.

Table 6 is an outline of the type of information that should be included in a typical SPDS for Milestone I. Note that the reference system is also described. Specific content

TABLE 5. EXAMPLES OF PRE-MEETING DISCUSSION TOPICS

Categories	Milestone I Army Helicopter	Milestone II Navy Attack Aircraft	Milestone III Air Force Fighter
Proposed System	Light Helicopter (LHX)	Attack Aircraft (VAX)	Fighter (FXX)
Reference System	Existing Observation Helicopter (OHY)	Existing Attack Aircraft (AYJ)	Existing Fighter (FYC)
Alternatives	Concepts: Modified OHY Austere LHX Existing Foreign Helicopter	Designs: Alternative Prototype VAX Modified AY	Acquisition Policy: Change Initial Production Rate Retrofit Subsystem Use Backup Subsystem
Contents of Cost Presentation (includes a review of the minimum requirements)	- SPDS (Reference System, Proposed System(s)) - Annual O&S Cost per Aircraft - Total Time-Phased O&S and Support Investment Costs - Helicopter O&S Cost Drivers - System Goals - Logistics Goals	- SPDS (Reference System, Proposed System(s)) - Annual O&S Cost per Squadron - Total Time-Phased O&S and Support Investment Costs - Annual Maintenance Cost by Subsystem (scheduled and unscheduled) - Historical Fighter and Attack Aircraft O&S Drivers, and their Estimates - System and Subsystem Goals	- SPDS (Reference System, Proposed System(s)) - Annual O&S Cost per Squadron - Total Time-Phased O&S and Support Investment Costs - Annual Maintenance Cost by Subsystem (scheduled and unscheduled) - Historical Fighter O&S Cost Drivers and Estimates - Progress in Meeting System and Subsystem O&S Goals
Special Issues	- Comparison of Alternative System Concepts - Sensitivity of LHX O&S Cost to Characteristics of Mission Equipment Package - Uncertainty in Estimates	- Risks in Engine Development and their Impacts on O&S Requirements - Alternative Support Strategies	- Use of Contractors for Initial Support - Funding of Reliability Improvement Program

TABLE 6. EXAMPLE OF A MILESTONE I SYSTEM PROGRAM DEFINITION STATEMENT FOR ADVANCED LIGHT HELICOPTERS

	Reference System	Proposed System
A. MISSIONS		
1. Primary	Reconnaissance, Command & Control, Scout	Scout
2. Secondary	Transportation	Reconnaissance, Command & Control, Transportation
B. CHARACTERISTICS		
1. Performance		
a. Maximum Speed/Range/Endurance	130 mph/260 Miles/3 Hours	150 mph/350 Miles/3.5 Hours
b. Maximum Rate of Climb[1]	1,800 ft./min.	2,000 ft./min.
c. Payload		
- Sea Level Standard Day[1]	455 lb.	1,000 lb.
- 6,000 ft. @90°F.	50 lb.	700 lb.
d. Mission Equipment Package (MEP)	None	Target Acquisition and Designation System; Pilot Night Vision System
2. Configuration		
a. Airframe	Aluminum; 2 passenger, 2 crew; skid landing gear	Aluminum and Composite; 2 pass., 2 crew; wheeled landing gear
b. Propulsion	One-Allison 763A-700 Turboshaft Engine with 317 SHP	One GE T700 Modular Turboshaft Engine with 1536 SHP; common to UTTAS & AAH
c. Rotors	2-17'8" Aluminum D spar; no damping	4-12' Fiberglass; elastomeric bearings damping
d. Avionics	Standard	Standard; Mission Equipment Package (MEP)
e. Empty Weight	1,530 lb.	4,000 lb. including 650 lb. MEP
3. Expected Operational Life	8 years (remaining)	15 years
C. ACQUISITION POLICY		
1. Design-to-Cost Goal (including the allocation of costs to hardware levels required by the O&S cost analysis)	None (unit cost $140K)	$1.1M prototype aircraft; $1.4M cumulative average cost at 100th production unit
2. Number of Aircraft	(normalized to 540 deployed aircraft)	
a. Deployed	540	540
b. Training	40	50
c. Pipeline	85	80
d. Attrition	35	30
3. Production/Deployment Schedule	8 per month for 2 years, then 16 per month to end of run	6 per year Low Rate Initial Production (LRIP) for 2 years, then 10 per mn. to end of run
4. Contract Commitments on Support Cost Control	None	RIW being considered
5. Special Considerations for Multi-National Application	None	None

[1] Different conditions including weight, configuration, and altitude from other stated characteristics.

	Reference System	Proposed System
D. DEPLOYMENT		
1. Number of Equipped Units CONUS/Overseas	40/14	
2. Average Aircraft per Unit	12	12
3. Flying Hours per Month Peacetime/Contingency	25/30	20/30
E. SUPPORT CONCEPT		
1. General Description	Transitioning to 3 level (AVUM AVIM, Depot) maintenance concept defined in published Maintenance Allocation Chart including 40% of on-equipment manpower expended on scheduled inspections. Engine teardown at Depot only.	Standard Army 3 level (AVUM AVIM, Depot) concept, greatly reduced scheduled inspections by applying on-condition maintenance philosophy. Engine modules will be interchangeable at intermediate level.
2. Skill Requirements	Low	Moderate (greater than for the Reference System)
3. Support Equipment	Simple	Complex for MEP
4. Contractor Support	None	Initial field and depot for MEP and engine. RIW items (if selected) for four years.
F. LOGISTIC GOALS		
1. Weapon System Goals		
a. System Reliability	1.5 MTBF	2.5 MTBF
b. Maintenance Man Hours per Flight Hour	5.1	6.0
c. Operational Ready Rate	70%	80%
d. Average Organizational/Intermediate Maintenance Men per Company	50	40
2. Subsystem Goals		
a. Engines		
1) Flying Hours Between Overhauls	750	2,000
2) Mean Flying Hours Between Failure (MFHBF)	44	100
3) Time Required to Change Engines	4 hrs.	2 hrs.
b. Avionics		
1) MFHBF	316 hrs.	100 hrs. (includes MEP)
2) Average Organizational/Intermediate Maintenance Men per Company	2	4
3. Component Goals		
a. Target Acquisition & Designation System		
1) MFHBF	N/A	200 hrs.
2) Unit Cost	N/A	$300K
b. Pilot Night Vision System		
1) MFHBF	N/A	350 hrs.
2) Unit Cost	N/A	$100K

will depend on the stage of the acquisition program, the type of aircraft, and the circumstances of its planned development, procurement, operation and support. The SPDS for the proposed system is expected to evolve as the aircraft design progresses through the acquisition process. The original SPDS should be retained, changes noted, and details added as uncertainty about the final design and deployment diminishes. It then becomes a record of the program as well as a description of the current situation.

D. O&S COST TRENDS AND GOALS

The DSARC wants every possible step to be taken towards managing and reducing future O&S costs for aircraft systems during the acquisition program. The proponent of a new aircraft must identify those factors that historically have accounted for the major portions of O&S costs (hardware or software characteristics, policies, and procedures); set program goals to reduce O&S costs; and specify program actions to attain those goals. Characteristics of, and policies for, the proposed weapon system that are different from those for the reference system and other relevant historical counterparts should be highlighted for specific analysis and presentation.

Tables 7 and 8 and Figure 4 illustrate several methods of presenting O&S cost trend and goal information to the DSARC. Table 7 illustrates the major O&S cost drivers for Army helicopters. Such presentations help to focus DSARC attention on the subsystems that have historically consumed the largest portions of maintenance resources for the

TABLE 7. HELICOPTER MAINTENANCE COST DRIVERS

System/Component/Activity	Percent of Direct Maintenance Cost (Parts and Labor)
Rotor System	29%
Hub - 20%	
Blades - 80%	
Power Plants	27%
Transmissions	12%
Inspections	9%
Other	23%

TABLE 8. PROGRAM ACTIONS TO REDUCE O&S COST

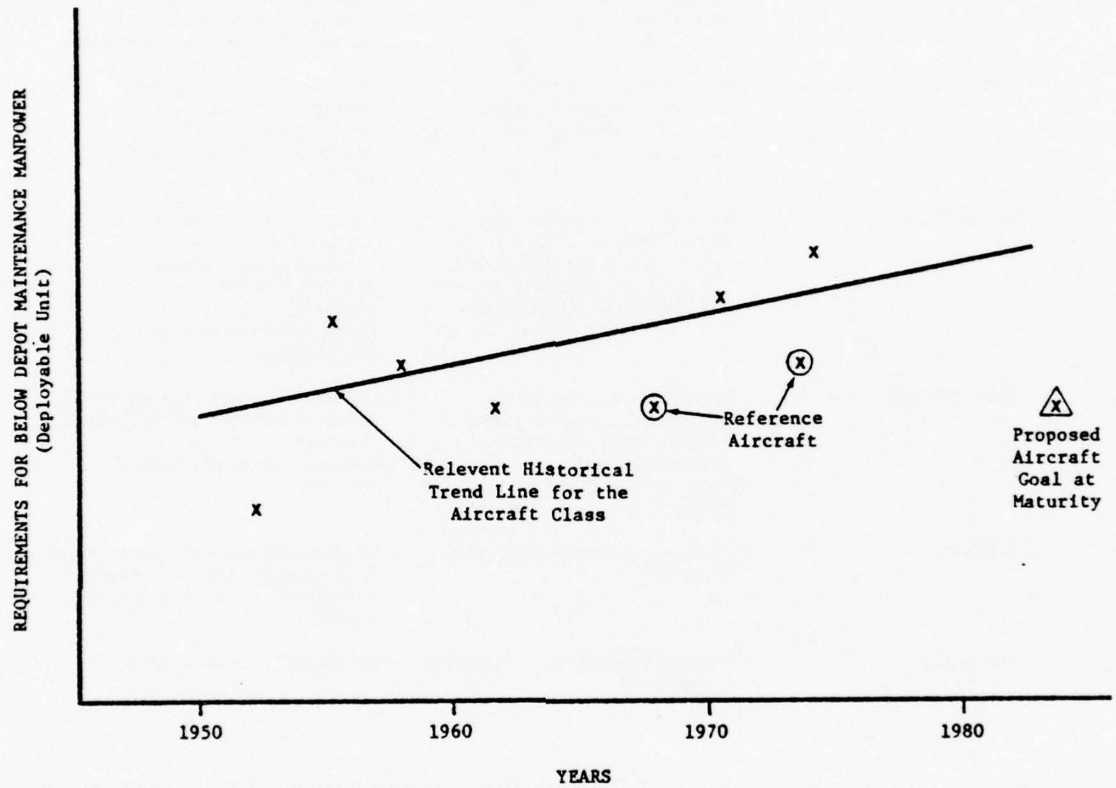
Helicopter Subsystem/Component	Major Historical Contributors to O&S Costs	Proposed System Cost Reduction Actions
Rotor Hub	Seal leaks result in fluid and lubricant loss	- Use elastomeric and dry lubricant bearings to eliminate sealing requirements
Rotor Blades	- Foreign object damage - Inability to repair damaged blades (1/2 removed are scrapped)	- Use composites in damage - susceptible blade areas to increase damage - tolerance characteristics and repairability
Power Plants	- No major contributor. Foreign object damage (11%) and improper maintenance (8%) are the most significant of 30 common causes of engine repair	- Design to incorporate an integral particle separator, fault isolation equipment, and engine history recorders - Test extensively in a dirty environment
Transmissions	- Scheduled overhaul (60%) - Overloads/stresses on bearings and gears due to excessive case deflection - Daily, intermediate and periodic inspections	- On-condition maintenance to increase overhaul and inspection intervals - Redesign for greater loads/ stresses
All Systems	- Vibration decreases reliability up to 50%	- Elastomeric bearings and dampers in the design of rotor hubs and transmission mountings reduce vibration
Inspections	- Daily, intermediate and periodic inspections	- On-condition maintenance

particular class of aircraft. Table 8 identifies the principal reasons why each specified helicopter subsystem has been an O&S cost driver, and lists current actions in the acquisition program to improve the characteristics of the proposed system to reduce O&S costs.

Figure 4 illustrates a graphical approach to presenting trend and cost-related goal information. It shows the historical trend for one support characteristic (the number of organizational maintenance personnel), the performance of the reference system with respect to that trend, and the goal for the proposed system at maturity. As the acquisition program progresses, the trend and goal information must be supplemented with information concerning progress towards established goals.

FIGURE 4. HISTORICAL TRENDS FOR AIRCRAFT MAINTENANCE MANPOWER

(Hypothetical)



E. SYSTEM-LEVEL COST ESTIMATES

The estimate of system-level O&S costs is a principal product of an O&S cost analysis. These estimates must be tailored to identify the O&S resource requirements for the proposed system, and to highlight the characteristics of the system relevant to DSARC issues. Tables 9 and 10, respectively, illustrate SI and O&S costs, for a hypothetical Navy Fighter at Milestone II, using the cost element structure presented earlier.

The first column of cost information in Tables 9 and 10 is for the reference system, which is defined as an existing system that either does, or could, perform the same general mission as the proposed aircraft and/or has the same general performance

TABLE 9. FLEET TOTAL SUPPORT INVESTMENT COSTS

(Millions of FY 75 Dollars)

(For a Hypothetical Navy Fighter at Milestone II)

Cost Element		Reference Aircraft	Proposed Program		
			Baseline	Current	Independent
202.1	Support Equipment	78.7	65.6	65.6	62.1
202.2	Training Equipment	87.1	92.0	94.1	96.3
202.3	Documentation	97.5	98.5	98.5	97.9
202.4	Initial Spares & Repair Parts	151.6	153.7	154.3	160.2
202.5	Spare Engines	62.3	84.1	84.1	84.1
202.6	Facilities (Non-Production)	16.5	17.0	18.0	21.3
202.7	War Reserve	20.0	20.0	20.0	20.0
202	Total Support Investment	513.7	530.9	534.6	541.9
	Range	± 3%	± 15%	± 12%	± 18%

TABLE 10. ANNUAL DEPLOYABLE UNIT OPERATING AND SUPPORT COSTS

(Millions of FY 75 Constant Dollars)

(For a Hypothetical Navy Fighter at Milestone II)

Cost Elements		Reference System	Proposed Aircraft		
			Baseline	Current	Independent
301	Deployed Unit Operations				
301.1	Aircrews	.31	.31	.31	.31
301.2	Command Staff	.48	.42	.41	.42
301.3	POL	1.26	1.35	1.35	1.35
301.4	Security	-	-	-	-
301.5	Other Deployed Personnel (non-maintenance)	-	-	-	-
302	Below Depot Maintenance*	2.91	2.78	2.76	3.05
303	Installations Support	.20	.20	.20	.20
304	Depot Maintenance	2.53	2.26	2.40	2.11
307	Personnel Support & Training	.98	1.00	1.00	.98
308	Sustaining Investments				
308.1	Replenishment Spares	1.10	.95	1.05	1.11
308.2	Modification Kits & Materiel	.20	.27	.27	.27
308.3	GSE	.13	.13	.13	.13
308.4	Training Ordnance & Materiel	.43	.43	.43	.43
	Total	10.53	10.10	10.18	10.36
	Range	± 5%	± 20%	± 18%	± 20%

*Reflects both shore and carrier-based intermediate maintenance resources called for by the mission scenario for a typical year of operations.

characteristics. The costs for the reference system, although based on historical experience, are normative costs. They reflect what the resource needs of the reference aircraft should be to satisfy the mission postulated for the proposed aircraft. The backup material must include historical costs of the reference aircraft, with an explanation of the adjustments made to derive the normative estimate.

Three cost estimates are shown for the proposed program. The first, labeled "baseline," is the original estimate presented to the DSARC at Milestone I. At each subsequent O&S cost presentation, the original estimate should be converted to the dollar base being used for the current estimate and resubmitted as a point of reference. The second, estimate labeled "current," is the system program manager's most recent cost estimate. Any major differences between it and the baseline must be explicitly annotated to explain the cause of the change (e.g., change in SPDS, data, or different cost-estimating method). The third estimate, labeled "independent," is the one developed by the Service independent cost analysis group. Any major differences between it and the current estimate also must be explained.

Table 11 provides the time-phased SI and O&S costs for the proposed aircraft. This presentation is useful to establish the long-term resource requirements for the proposed system, and can also be used as an input to force structure impact analyses.

Table 12 provides a more detailed breakout of the annual maintenance costs of both the reference and proposed systems. In this presentation, selected subsystems have been identified and their associated maintenance costs broken out. This kind of display is often useful to indicate subsystem O&S cost visibility, and to identify any questionable trends.

F. MICRO-COST ANALYSES

The preceding illustrations have addressed information called for in the normal DSARC requirements. This section describes procedures for conducting in-depth reliability versus support cost analyses. These analyses are implicit in many decisions made during an acquisition program and are included in this discussion to give Program Managers and Defense contractors an idea of the type of analyses that can be conducted

TABLE 11. TIME-PHASED SUPPORT INVESTMENT AND OPERATING AND SUPPORT COSTS

(Millions of FY 75 Dollars)

(For a Hypothetical Navy Fighter at Milestone II)

	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89	Total: FY 90 to FY 01	Total
Number of Aircraft											
Deployed Units (cumulative)	0	12	48	48	84	108	144	168	192	Ave. of 174	216 (max)
Training Units (cumulative)	0	23	23	46	46	46	46	46	46	Ave. of 46	46
Proposed System											
Support Investment	71.8	112.0	81.2	77.4	93.5	35.4	23.1	18.4	1.8	20.0	534.6
O&S	0	33.0	66.2	88.1	118.2	139.7	172.0	193.5	215.1	2,387.0	3,412.8
Total	71.8	145.0	147.4	165.5	211.7	175.1	195.1	211.9	216.9	2,387.0	3,927.4

NOTE: Assumptions about the lead time allowances for capital investments of support equipment, spares, etc., and the system maturation process must be documented in the backup material.

to determine the cost effectiveness of alternative aircraft components. While the results of these analyses are useful to the Military Departments and contractors for making detailed weapon configuration decisions, they are generally not applicable to the broad-base review requirements of the DSARC/CAIG.

Such analyses have been termed "micro-analyses." They normally involve only a small portion of total cost, and/or focus on selected subsystem or support policy trade-offs. Nonetheless, their importance to O&S cost analysis is immense, because they can influence major program decisions.

Three examples are presented. The first sketches a Maintenance Support Requirements analysis (see Section V). The second illustrates the presentation of a sensitivity analysis. The third demonstrates some of the interactions among design characteristics that influence O&S costs. All three examples are intended to convey the flavor of micro-analysis of O&S costs, and not to specify a particular procedure or format.

TABLE 12. COMPARISON OF SELECTED ANNUAL COSTS OF AIRCRAFT MAINTENANCE FOR SELECTED SUBSYSTEMS

(Thousands of FY 75 Dollars per Aircraft)

(For a Hypothetical Navy Fighter at Milestone II)

Cost Elements	Reference System	Proposed System*
Below Depot Maintenance	230.1	243.0
Scheduled	148.3	152.8
Unscheduled	81.8	90.2
Airframe	29.1	32.7
Engines	15.4	15.4
Avionics	29.9	33.5
Radar	13.4	16.4
Inertial Nav. Sys.	10.4	10.4
Other	6.1	6.7
Armament	7.4	8.6
Depot Maintenance	200.0	212.7
Airframe	39.3	42.3
Engines	39.6	39.6
Avionics	121.1	130.8
Total Annual Cost of Maintenance per Aircraft	430.1 ± 8%	455.7 ± 15%

*Characteristics at maturity and steady state operations assumed.

1. Maintenance Support Requirements (MSR) Analysis

Table 13 outlines a typical MSR analysis. In this example, the objective is to compare the below depot maintenance manpower requirements of two alternative subsystems. The choice is essentially a trade-off between the shorter average repair times for Alternative #1 and the better reliability of Alternative #2. The first calculation computes the differences in hardware-driven requirements in terms of maintenance manhours per flying hour (MMH/FH). The differences in requirements are then translated into a manpower impact. The manpower impact is a result of both hardware and policy-driven requirements, and, in most cases, also will depend upon other system requirements. For example, in Table 13 the .05 difference in INT MMH/FH (calculated requirements) would amount to about 3.5 MMH/day in a typical Air Force fighter wing. Only by considering deployment needs, organizational practices, manning policies, and other

TABLE 13. MAINTENANCE SUPPORT REQUIREMENTS ANALYSIS

Cost Element of Interest: Below Depot Maintenance (302)

Equations: 1. Organizational Maintenance = [Number of Maintenance Actions per Flying hour] X [Mean Time to Fault Isolate, Access and Repair or Replace]

$$\text{ORG.MMH/FH} = \frac{UF}{MTBF}\left[PAMH + (RIP)\ (IMH) + (1\text{-}RIP)\ (RMH)\right]$$

2. Intermediate Maintenance Manhours per flying Hour = [Number of Removals per Flying Hour] X [Mean Time to Repair]

$$\text{INT.MMH/FH} = \frac{UF}{MTBF}\left[(1\text{-}RIP)\ (MTTR)\right]$$

Data:

SYMBOL	DEFINITION	SUBSYSTEM ALTERNATIVE #1	SUBSYSTEM ALTERNATIVE #2
UF	Ratio of operating hours to flying hours	1.25	1.25
MTBF	Mean operating hours between failures	10 hrs.	15 hrs.
PAMH	Average manhours for preparation and access	.50 hrs.	.75 hrs.
RIP	Fraction of failures which can be repaired in-place	.20	.40
IMH	Average manhours to isolate fault, repair in-place, and check out	.25 hrs.	1.50 hrs.
RMH	Average manhours to isolate fault, remove and replace	.75 hrs.	1.0 hrs.
MTTR	Average time for shop maintenance, including diagnostics, repair, and check out	2 hrs.	3 hrs.

CALCULATED REQUIREMENTS:

	ALT. #1	ALT #2	(#1) - (#2)
ORG.MMH/FH	.144	.162	-.018
INT.MMH/FH	.200	.150	.050
TOTAL MMH/FH	.344	.312	.032

MANPOWER IMPACT:

ORGANIZATION MAINTENANCE MANPOWER: NONE

INTERMEDIATE MAINTENANCE MANPOWER: ALTERNATIVE #1 requires three additional technicians per wing @ $10,000 per year each.

PREFERRED ALTERNATIVE: #2

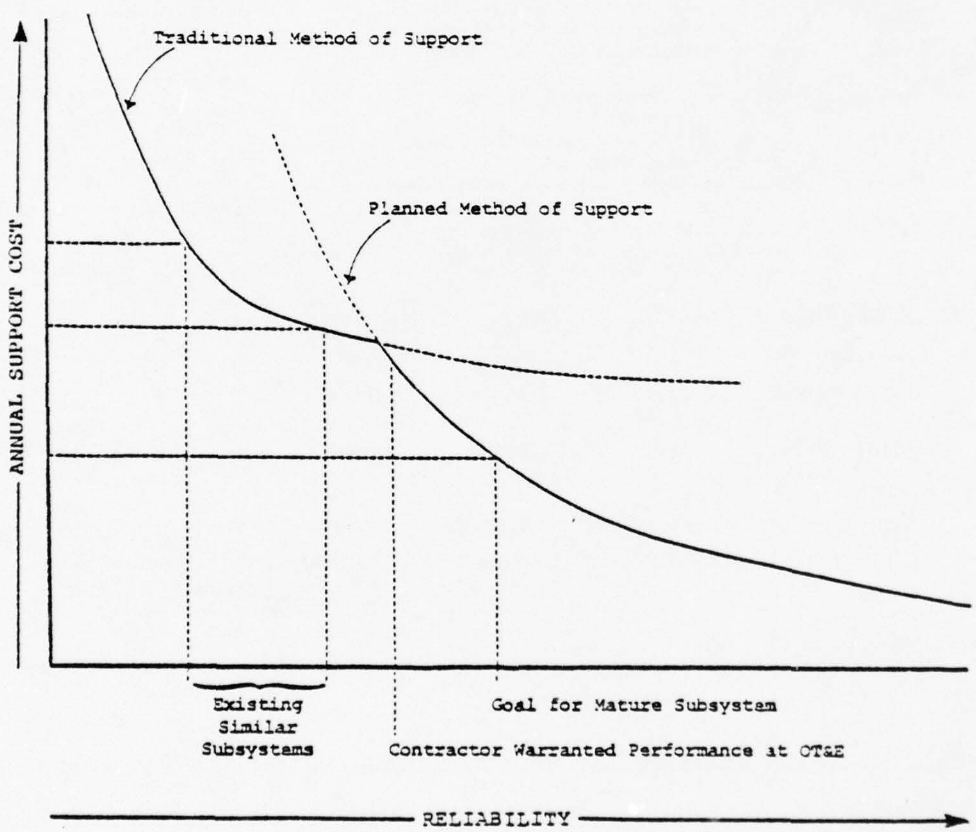
requirements for intermediate maintenance technicians of the same skill could the need for these additional technicians be identified. The preferred alternative is #2, because the total below depot maintenance impact for Alternative #1 requires three additional technicians per wing.

2. Sensitivity Analysis

The O&S cost estimate for an aircraft is frequently based on the assumption that specified program goals will be attained. The DSARC should be informed of the confidence in achieving these goals and the consequences of not reaching these goals.

Figure 5 illustrates the results of a hypothetical analysis of the sensitivity of a subsystem's support cost to reliability. The curve labeled "Traditional Method of Support" shows the estimated annual support cost of the subsystem over the range of reliabilities experienced on existing similar subsystems. It also indicates that if this traditional method of support is used, further improvement in reliability will not substantially reduce support costs. The knee of the curve has been passed, and the curve flattens very quickly.

FIGURE 5. SENSITIVITY OF SUBSYSTEM SUPPORT COST TO RELIABILITY



The other curve, "Planned Method of Support," shows the sensitivity of annual support cost to the reliability of the proposed subsystem, and allows for a method of support different from that used for existing similar subsystems. On this curve, the estimated annual support costs associated with both the contractor-warranted reliability,

and the reliability goal for the mature subsystem are identified. Clearly, if the reliability goal is reached, the planned method of support offers substantial reductions in annual support cost. However, the curves also illustrate that the feasibility of the planned method of support depends upon achieving a much better level of reliability than that experienced on any existing similar subsystem. If the reliability of the proposed subsystem proves no better than that of existing similar subsystems, the traditional method of support will be preferred.

This sensitivity analysis conveys two important messages to the acquisition manager and the DSARC. First, the reliability of the proposed subsystem is critical. The goals established are high, and development and procurement costs for the subsystem will reflect the expense of efforts to meet them. If the chances of actually achieving the reliability goals are not good, it might be wise to lower them to the range for existing similar subsystems, and plan to support the subsystem in the traditional manner. This should reduce the development and procurement costs, as well as the program risk. If the established reliability goals are determined to be realistic, and probably attainable, the subsystem's reliability must then be monitored closely throughout the development, testing, and initial operating phases of its life cycle. Any failure to meet interim reliability objectives would signal potential problems that might necessitate change in the support concept.

The second message conveyed by the sensitivity analysis is that the design of the subsystem must not prohibit either method of support. If the subsystem's reliability meets program goals, implementation of the planned method of support would be advantageous. But if the subsystem's reliability proves disappointing, support comparable to that for existing similar subsystems would be desirable.

3. Subsystem Trade-off Considerations

a. Introduction

A fundamental purpose of the DSARC process is to seek improvements in the proposed system that will result in lower O&S costs, and still satisfy the given mission

requirements. Such analyses invariably involve trade-offs between the present costs of a design or policy change, and future cost savings. Often these trade-off analyses are used to determine threshold or breakeven conditions, where the relative merits of designs or policies can be demonstrated. In general, every significant O&S cost driver should be analyzed to determine those conditions where a design or policy could be improved or changed that could potentially yield O&S cost savings.

Investigating trade-offs among cost, design, and policy is important throughout the DSARC process. Investigation of design and policy changes prior to their "hard" definition is preferred. The following example is an illustration of how certain design characteristics of an avionics subsystem (e.g., a forward-looking radar, inertial measurement system, etc.), can be reviewed early in the acquisition program.

b. Setting

Assume that a new weapon system has been proposed, and the funding for conceptual development has been approved at Milestone I. In the meetings prior to Milestone II, several O&S cost drivers have been identified as candidates for possible design changes and management control actions. Avionics fault isolation problems in particular have been identified as an important O&S cost driver in the reference system. Historical trends indicate that fault isolation difficulties will increase, and continue to prevent the achievement of desired operational readiness (OR) rates, in addition to increasing O&S costs.

The following information is available from the SPDS.

- The reference avionics system has four modules, and the proposed system is expected to have eight.
- The reference avionics system has an average aggregate failure rate of 24 per 1000 operating hours, or an MTBF of 41.7 hours (to be referred to as the nominal failure rate). The proposed system is planned to have a 50% lower aggregate failure rate of 12 per 1000 operating hours, or an MTBF of about 85 hours. (Note that the

nominal aggregate failure rate for all the systems considered is 24 per 1000 operating hours.)

- The proposed avionics system is expected to have an average fault isolation or diagnosis accuracy of twice that of the reference system.
- The reference system cost per module is $30,000.

The proponent Military Department wants to increase modularity in the proposed design in order to: isolate the high-technological-risk components more easily; reduce fault isolation and remove and replace times; reduce total avionics spares requirements; and, increase the opportunities for selective reliability improvement programs.

In the pre-DSARC meeting discussions, it has been agreed that the Military Department will analyze and present the impact of alternative avionic subsystem designs with different reliability and fault isolation conditions on selective O&S cost elements. The CAIG has specifically asked the Military Department to submit a formal analysis of potential trade-offs between reparable spares investment costs, and different module configurations (two, four, eight), as a function of reliability and fault diagnosis accuracy. Breakeven points must be identified where the spares investments for the different configuration, reliability and fault diagnosis combinations are equal. Note that for the purposes of this illustration, only the spares costs are estimated.

c. Analysis

The proposed avionics subsystem is expected to have eight modules, but two- or four-module configurations are feasible. The question is, "Under what reliability and diagnosis accuracy conditions will one design be preferred over the others with respect to spares investment costs?" The following assumptions have been made:

- The costs of designing a two-, four-, eight-module configuration are essentially the same.
- The spares costs are computed for different modules, reliabilities and fault isolation accuracies. Aircraft utilization, or flying hour program is held constant. In this instance, a peacetime flying hour

program of about 25 hours per month per aircraft for a fleet of about 400 aircraft is assumed. In the event of a Not-Operationally-Ready aircraft due to Spares (NORS) occurrence, this flying schedule is maintained so that the failure rate is held constant. For each module, spares are obtained as suitable multiples of pipeline quantities so that a stated level of NORS aircraft is achieved. (Spares volume discounts are not considered.)

- The failure rates (per operating hour), based on the reference system's nominal failure rate, for the different configurations are aggregated as in Table 14.

TABLE 14. MODULE FAILURE RATES

(Proposed) 8-Module Configuration	(NOMINAL) Failure Rate*	(Reference System) 4-Module Configuration	(NOMINAL) Failure Rate*	(Alternative) 2-Module Configuration	(NOMINAL) Failure Rate*
1	.001	1	.006	1	.013
2	.005				
3	.004	2	.007		
4	.003				
5	.005	3	.006	2	.011
6	.001				
7	.002	4	.005		
8	.003				
	.024		.024		.024

*Failures per operating hour.

4) The spares costs of the different configurations are estimated to be as in Table 15.

5) The repair of all modules will require about the same level of effort for the different configurations, and the pipeline times (base and depot repair) are about the same. No cannibalization is assumed.

TABLE 15. MODULE SPARES COSTS

Configuration	Cost per Module	Subsystem Costs
2-Module	$40,000	$ 80,000
4-Module (Reference System)	$30,000	$120,000
8-Module (Proposed)	$20,000	$160,000

(Penalties reflecting extra expenses and weights normally incurred for separate packaging, interfaces, and connectors are incorporated in these costs)

6) All modules are like LRU's in that they can be removed and replaced independently of one another.

7) Support equipment costs and maintenance personnel costs are the same for all configurations. Also, there are no support equipment capacity constraint problems.

8) The percentage of repairs made at the base (as opposed to the depot) is about the same for the different configurations.

If the diagnosis of a fault were perfectly accurate, then only the failed module would be removed. However, more than one module may be removed from the aircraft, at the same time or sequentially, because of incorrect diagnosis or a desire for quick turnaround. More than one of the removed modules may be sent to the base/depot for repair because of incorrect fault diagnosis, or because the mechanic cannot afford to wait for the repair of one unit to be sure that another is working properly.

If one module at a time is removed, tested and repaired (when required) from an N-module configuration, where each module is equally likely to fail, and successive modules are removed until the failed one is identified, the expected number removed is $\frac{(N+1)}{2}$. For the purpose of this illustration, the accuracy of removal and

selection for inspection and repair (considered as one operation) is represented by:

$$\rho = 1 - \frac{(\text{Average Number of Modules Removed} - 1)}{\frac{(N-1)}{2}},$$

where ρ is the diagnosis accuracy index which can take on values between 0 and 1. (Note this is not a probability of correct fault isolation.) For this measure:

- If the average number removed is 1, then there is perfect diagnosis and subsequent repair, then $\rho = 1$; and
- If the average number removed is $\frac{N+1}{2}$, then there is a random search, the diagnosis accuracy index, $\rho = 0$.

It is possible to do worse than a random search. Such a situation could result from the removal of modules for a problem incorrectly associated with that subsystem. Software problems have been known to cause such unnecessary removals. However, in this instance, it is assumed that a random search approach is the "worst" expected case for diagnosing failures. Conversely, the best case is perfect diagnosis. Therefore, all the likely fault diagnosis cases can be reflected as having values of ρ between 0 and 1.

In order to reflect the possible range of reliability conditions, several multiples of the reference system nominal failure rate will be investigated. The cases to be analyzed are: one-half of the nominal failure rate (the best case), the nominal failure rate (the reference system value, and the most likely case), and twice the nominal failure rate (the worst case). The methodology used in this analysis is illustrated schematically in Figure 6.

d. Results

The results of this analysis of the trade-off relationships among different configurations, reliability, diagnosis accuracy, and NORS rates and spares costs are illustrated in Figures 7 to 9. These comparisons are most easily understood by fixing a required NORS rate, say at 5%, for the avionics subsystem, and then observing the

FIGURE 6. METHODOLOGY TO COMPUTE AVERAGE NORS VS SPARES AS A FUNCTION OF NUMBER OF MODULES, RELIABILITY AND FAULT DIAGNOSIS ACCURACY

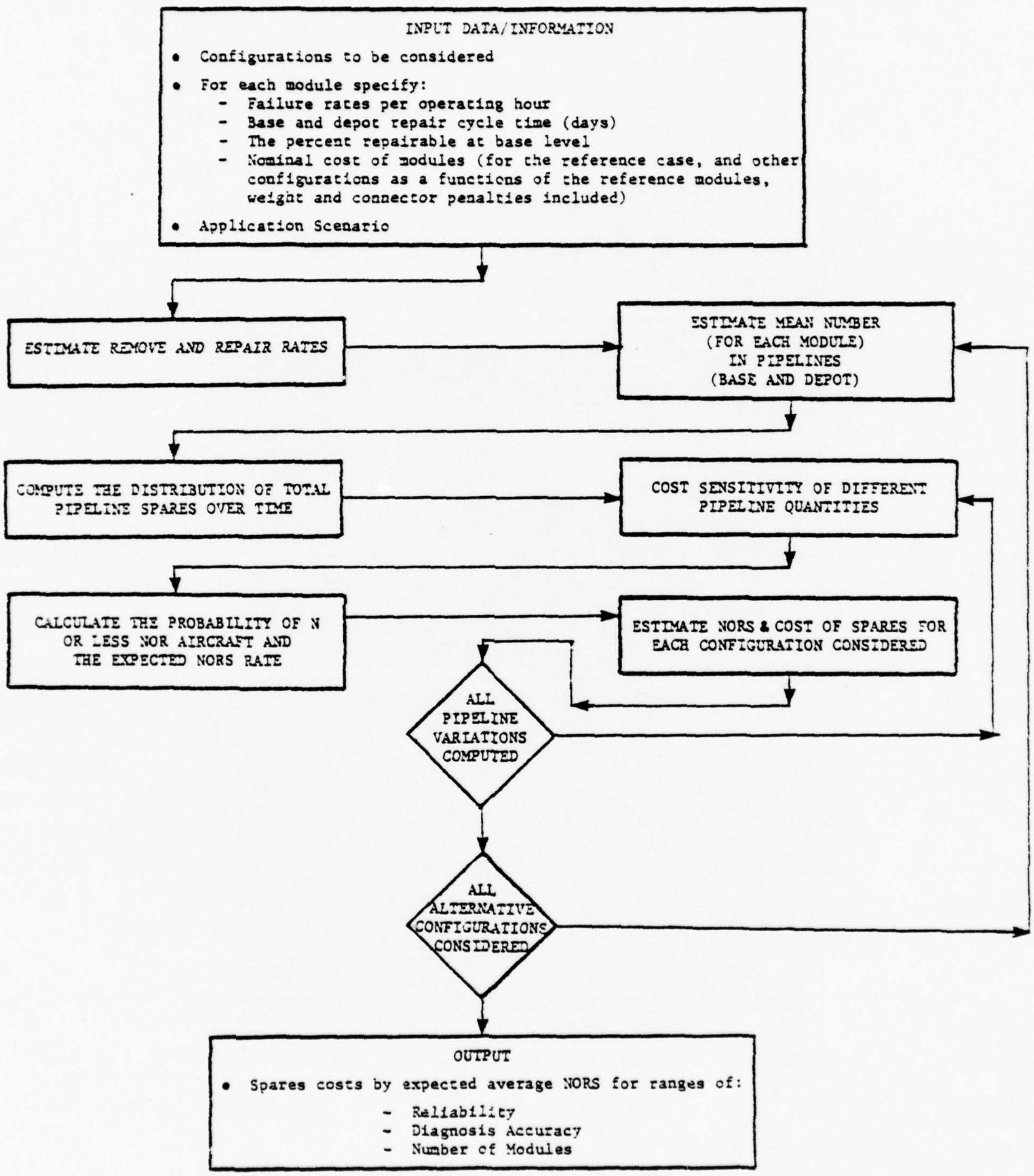


FIGURE 7. SPARES VS AVERAGE NORS: RANDOM DIAGNOSIS

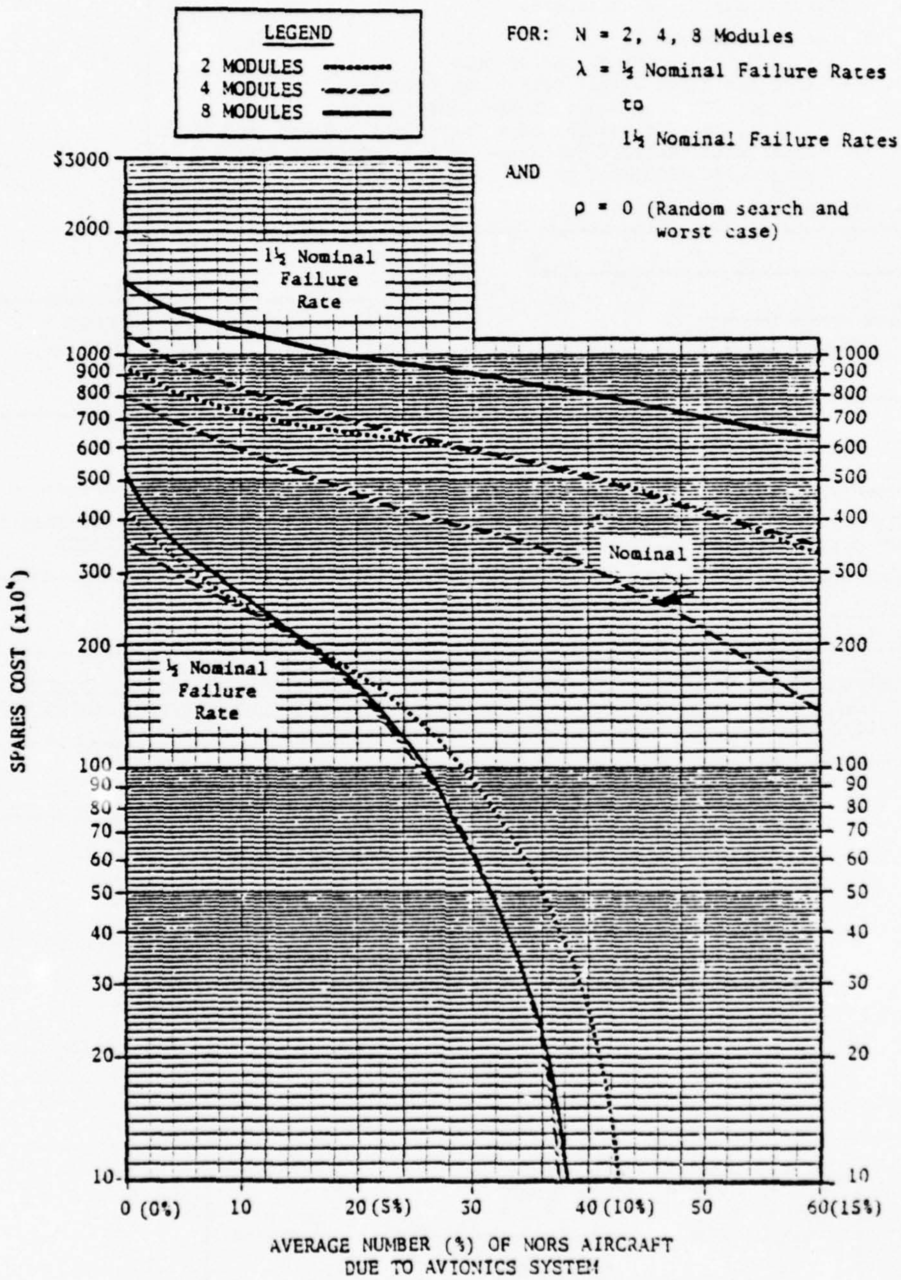


FIGURE 8. SPARES COST VS AVERAGE NORS: EQUAL MIX OF PERFECT AND RANDOM DIAGNOSIS

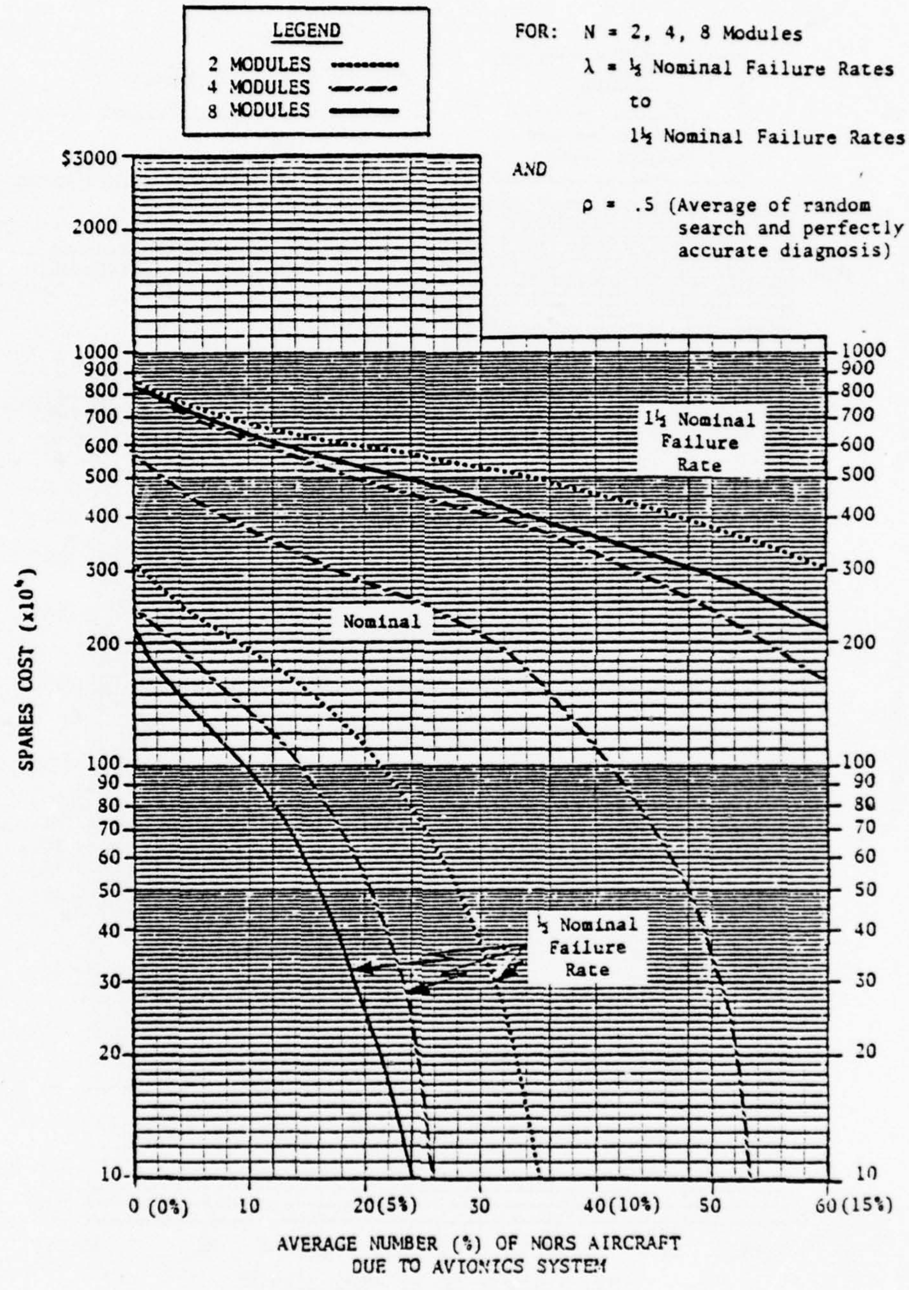
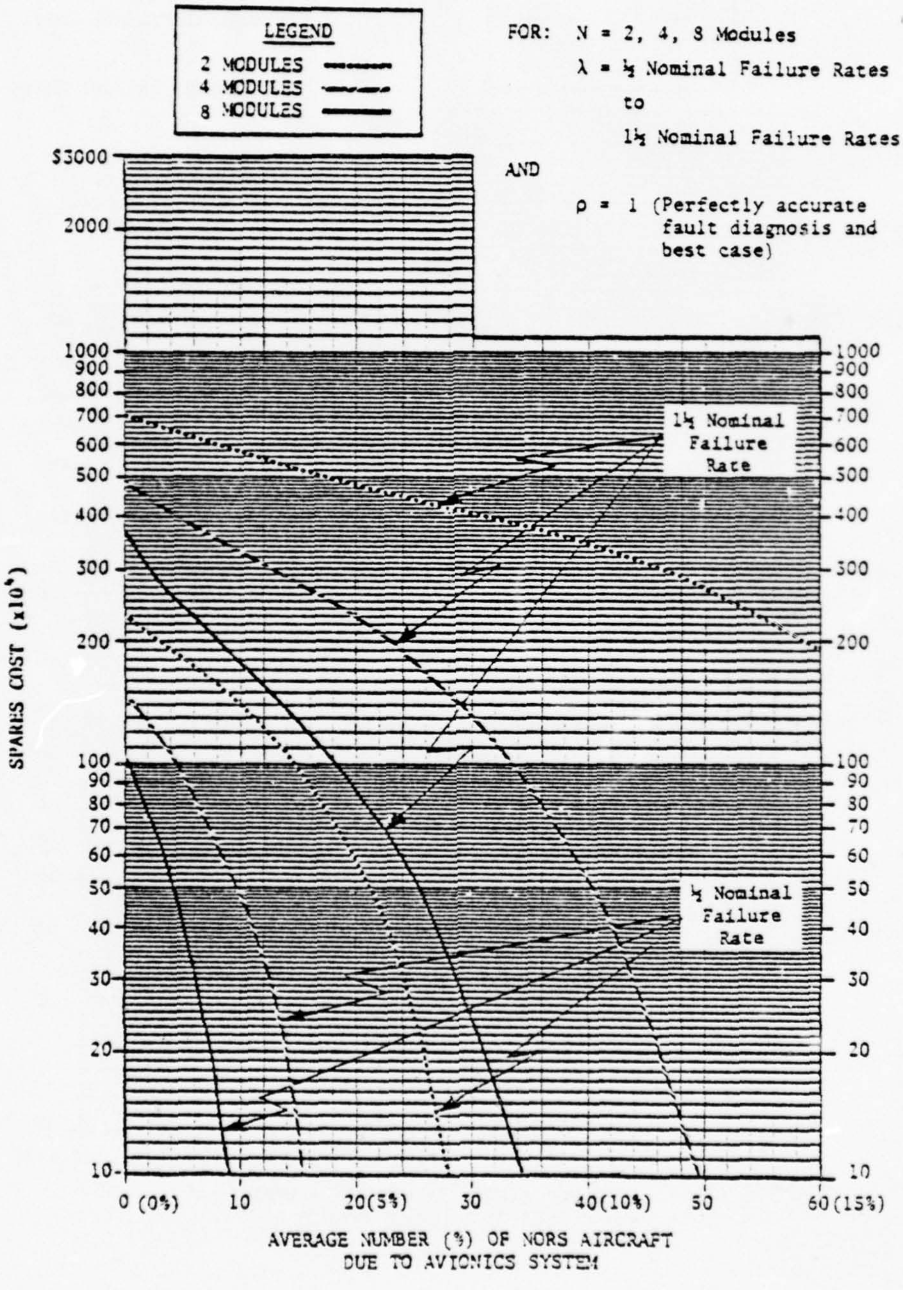


FIGURE 9. SPARES COST VS AVERAGE NORS: PERFECT DIAGNOSIS



comparative advantages in terms of spares investment for the different modular configurations at the different reliability and diagnosis accuracy rates. To assist in these comparisons, the candidate designs (N=2 and 8) are defined as multiples of the reference system (N=4), and the reliability ranges are defined as one-half and one and one-half times the nominal or reference system reliability.

When the fault diagnosis accuracy is no better than that for a random search strategy (ρ=0, Figure 7), increasing the number of modules from four to eight could, in the low reliability case (one and one-half the nominal failure rate), increase the required spares investment by 50% for a constant 5% NORS requirement. For the high reliability case (one-half the nominal failure rate), increasing the number of modules from four to eight yields about the same spares investment requirement at the 5% NORS rate. The dramatic savings for this low diagnostic accuracy situation are clearly derivable from an increase in the reliability of the avionics system, and not from an increase in modularity.

As the diagnosis accuracy increases to where there is an equal mix of perfect and random diagnosis (ρ=0.5, Figure 8), the comparative advantage of increasing the number of modules improves relative to the worst (ρ=0) diagnosis accuracy case. However, the dominant leverage to reduce the spares investment is still through reliability improvement for this level of diagnosis accuracy.

For the perfect diagnosis case (ρ=1, Figure 9), increasing the number of modules has a substantial payoff in the reduction of spares investment over the nominal (reference) case. In fact, the eight module configuration, with a 50% degradation in reliability over the nominal reliability, requires virtually the same spares investment as the reference four-module configuration of the nominal failure rate. The spares requirements for the eight-module configuration at one and one-half the nominal failure rate are virtually congruent with the reference four module configuration at the nominal failure rate. The eight-module configuration at the nominal or one-half the nominal

failure rate, with perfect diagnosis, provides a 5% NORS rate at virtually no spares investment.

A useful way to portray these results is shown in Figure 10. In that illustration the crossover or breakeven points, in terms of the spares investment for a 5% NORS rate, for the two-, four-, and eight-module cases of different reliabilities and diagnostic accuracies are shown. The important points are:

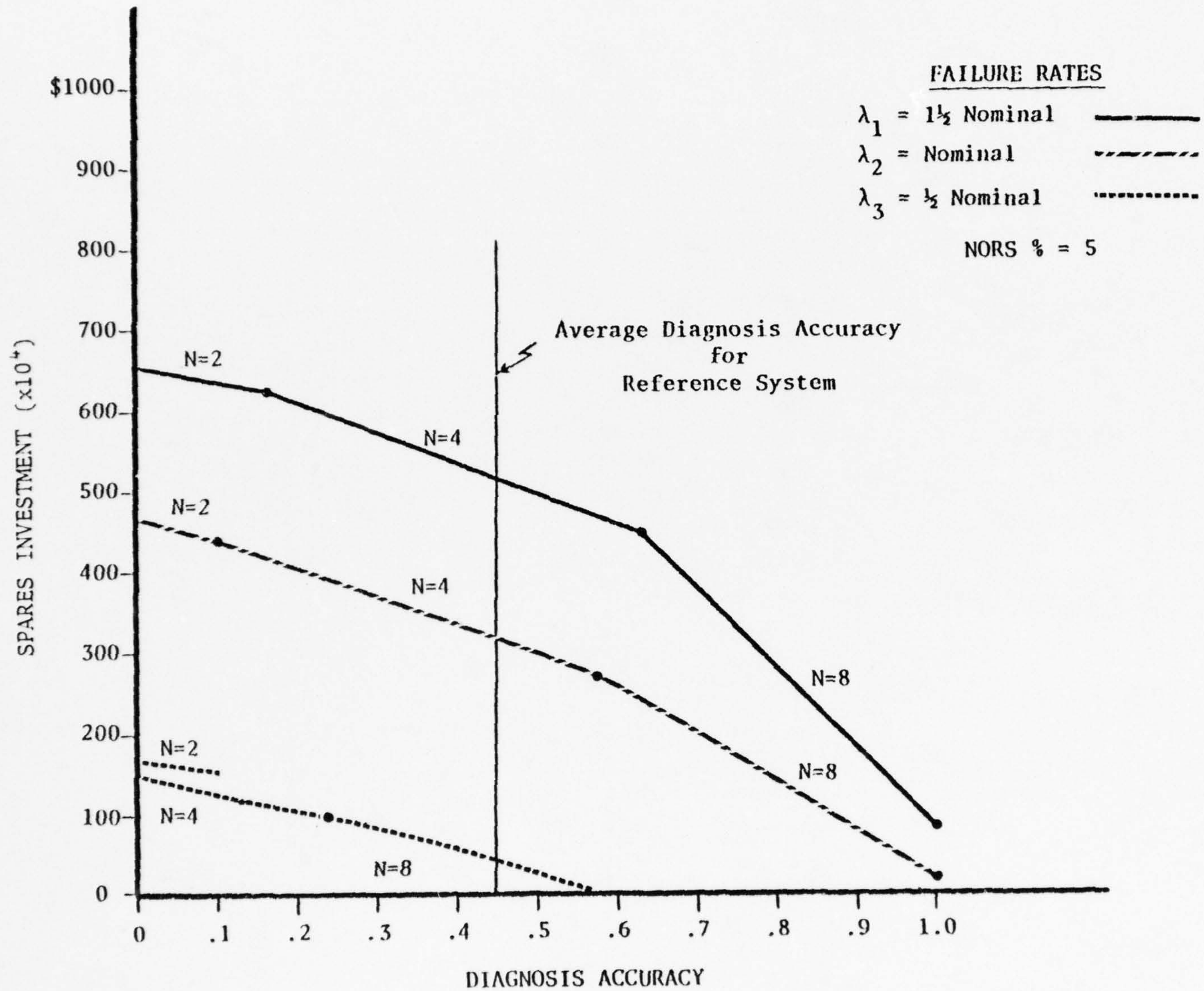
1) Modularity pays off only if the diagnostic accuracy is high enough. In this case, the eight module configuration requires fewer spares than the four-module configuration, at the low or nominal reliability levels, when the diagnostic accuracy is approximately ρ=0.60 or higher. When the reliability is high (one-half the nominal failure rate), the diagnostic accuracy need only be about ρ=0.25 or higher for the eight-module design to require a lower spares investment than the reference four-module design.

2) The existing design (four-module) with a diagnostic accuracy of around ρ=0.45 was a good selection for the reference system. At the same reliability level, the proposed configuration must exhibit at least a 30% improvement in diagnosis accuracy in order to save on spares costs.

3) In order for the DSARC to be confident that the proposed system will require lower spares costs, a specific test and demonstration program must be developed and monitored to ensure that the necessary reliability and diagnosis accuracy are achieved.

The above example illustrates the kind of analysis that could be carried out prior to the actual design of the proposed avionics concept. It could be discussed at the Milestone II in terms of feasible regions, O&S cost crossover points, and selective demonstration requirements.

FIGURE 10. SPARES INVESTMENT VS DIAGNOSIS ACCURACY



APPENDIX A

100 RESEARCH AND DEVELOPMENT: (Includes the cost of Development Engineering, Producibility Engineering and Planning, Tooling, Manufacturing Prototypes and MIL STD 881 Category Systems Test and Evaluation)

200 INVESTMENT:

201 SYSTEM INVESTMENT: The flyaway cost of the aircraft (see DoD 7110-1-M, Department of Defense Budget Guidance Manual) plus any other costs to the Government of producing or procuring the aircraft, managing the acquisition program, and delivering the aircraft to initial operational units. Includes the following MIL STD 881 categories: Air Vehicle and System/Project Management.

202 SUPPORT INVESTMENT: The sum of cost elements 202.1 through 202.7.

202.1 Support Equipment: The cost of acquiring peculiar and common equipment and software needed for operating, testing, repairing, or otherwise supporting the aircraft, its subsystems (engines, avionics, armament, etc.) and support equipment.

202.2 Training Equipment and Services: The cost of acquiring and installing training equipment and software, including simulators, includes the cost of training initial operator, maintenance, and instructor personnel; excludes the pay, allowances and travel of trainees, which are included in cost element 307. (See Note 1.)*

202.3 Documentation: The cost of gathering, storing, reproducing, and disseminating technical and managerial data and the cost of preparing, updating, and reproducing publications such as technical manuals.

202.4 Initial Spares and Repair Parts: The cost of secondary item spares and repair parts needed for support of a new aircraft during the initial period of operating service, normally not longer than two years from the date of initial operational capability (IOC). Excludes spare engines and engine modules and cryptologic equipment. (See Note 2.)

202.5 Spare Engines: The cost of spare engines and spare modular engine components needed to support the planned aircraft flying program. Includes engine war reserve requirements. (See Note 2.)

202.6 Facilities (Non-production): The cost of construction, conversion or expansion of facilities required for operation or support of the aircraft, its subsystems, or support equipment. Includes MIL STD 881 cost categories Operational/Site Activation and Industrial Facilities (non-production).

202.7 War Reserve Materiel: The cost of establishing or increasing stocks of materiel amassed in peacetime to meet wartime stock requirements. Excludes spare engines and engine modules.

*Notes for Appendix A are at the very end of Appendix A.

300 OPERATING AND SUPPORT: The variable cost of operating and supporting a weapon system including contractual support.

301 DEPLOYED UNIT OPERATIONS The cost of deployed unit manpower (for example, crews, command staff and security personnel); POL; and other operating expenses chargeable to the non-maintenance activities of a deployed unit including contractual support. A deployed unit consists of any unit operating in the field for combat, training or other operating purpose. (See Note 3.)

301.1 Aircrews: The cost of paying the full complement of aircrews required to man unit aircraft. Included are all aircrew personnel necessary to meet: combat deployment requirements, training requirements, and administrative requirements, such as leave.

301.2 Command Staff: The cost of paying the personnel required for unit flying supervision. These personnel perform such jobs as command, operations control, planning and scheduling, flying safety, quality control on aircrew training and flying proficiency, and include the combat commander, the squadron commanders and their respective staffs.

301.3 POL: The cost of aviation petroleum, oil and lubricants required for peacetime unit flying operations, including allowances for distribution, storage and spillage.

301.4 Security: The cost of paying personnel needed for unit aircraft equipment security, for example, entry control, close and distant boundary support, and security alert teams.

301.5 Other Deployed Manpower: The cost of paying all other personnel (for example, public information and social action people) assigned to a typical deployed unit during peacetime, except those personnel included in cost elements 301.1 (Aircrews), 301.2 (Command Staff), and 302 (Below Depot Maintenance).

301.6 Personnel Support: The cost of supplies, services and equipment needed to support deployed unit personnel. Examples of costs included are: administrative supply items, travel expenses, expendable office machines and equipment, custodial services, and other variable personnel-oriented support costs incurred at the deployed unit.

302 BELOW DEPOT MAINTENANCE: The cost of manpower and materiel needed for maintenance of deployed unit aircraft, support equipment and ordnance, including contractual support. (See Note 4.)

302.1 Aircraft Maintenance Manpower: The cost of paying the personnel needed to meet below depot maintenance requirements (including contractor support) of the deployed unit. Included are personnel needed to meet the maintenance demands of the assigned aircraft and aircraft support equipment, precision measurement equipment, laboratory equipment, and training simulators and support equipment; to provide for maintenance supervision and control; and to cover administrative requirements, such as leave.

302.2 Ordnance Maintenance Manpower: The cost of paying the personnel needed for: loading, unloading, arming and disarming of munitions and missiles; inspection, testing and maintenance of all aircraft weapons release systems; maintenance, ammunition loading, activation and deactivation of aircraft gun systems; and maintenance and handling of the munitions and missile stockpile authorized by the WRM plan.

302.3 Maintenance Materiel: The cost of purchasing materiel from the General and System Support Divisions of the Stock Fund. This includes only non-reparable expense items consumed in the repair process. Excludes reparables procured from the Stock Fund, which are included in cost element 308.1 (Replenishment Spares).

302.4 Personnel Support: The cost of supplies, services and equipment needed to support below-depot maintenance personnel. Examples of included costs are administrative supply, items, travel expenses, expendable office machines and equipment, custodial services, and other variable personnel-oriented support costs incurred at the maintenance activities.

303 INSTALLATION SUPPORT: The variable cost of providing support for deployed unit personnel at the unit's support installation(s). Includes contractual support.

303.1 Base Operating Support: The cost of installation personnel and materiel necessary to directly support the deployed unit. Examples of installation functions which directly support the unit include: food service, supply, and motor pool operations. These personnel and materiel costs would no longer be incurred by the installation if the deployed unit were moved elsewhere.

303.2 Real Property Maintenance: The variable costs of construction, maintenance and operation of real property facilities, and related management and engineering support work and services.

303.3 Personnel Support: The cost of supplies, services and equipment needed to support installation support personnel. Examples of included costs are: administrative supply items, travel expenses, expendable office machines and equipment, custodial services, and other variable personnel-oriented support costs incurred at the installation(s).

304 DEPOT MAINTENANCE: The cost of manpower and materiel needed to perform aircraft and aircraft component and support equipment maintenance at DoD centralized repair depots (including contractual support) and contractor repair facilities.

304.1 Manpower: The cost of labor needed to perform major overhaul, repair, modification, inspection, and storage and disposal of aircraft and aircraft components and support equipment. Includes variable overhead for organic repair.

304.2 Materiel: The cost of materiel consumed in the depot overhaul, repair, inspection and storage and disposal process.

305 DEPOT SUPPLY: The cost of manpower and materiel needed to buy, store, package, manage and control the supplies, spares and repair parts used in operating and maintaining aircraft and aircraft components and support equipment; and to provide sustaining (service) engineering and technical data support for aircraft systems. Includes contractual support.

305.1 Materiel Distribution: The cost of manpower and materiel needed to fill requisitions for supplies, spares and repair parts. Included are receiving, unpacking, storage, inspection and packing and crating costs.

305.2 Materiel Management: The cost of manpower and materiel needed to manage the procurement of supplies, spares and repair parts and maintain control and accountability of these assets. (See Note 5.)

305.3 Technical Support: The cost of sustaining (service) engineering and technical data and documents needed to perform sustaining engineering and maintenance on aircraft components and support equipment.

306 SECOND DESTINATION TRANSPORTATION: The round-trip cost of transporting engines and engine components, ground support equipment and reparable secondary items to depot maintenance facilities and back to the operational unit or CONUS stock points, and the one-way cost of transporting repair parts from CONUS stock points to depot and below depot maintenance activities.

307 PERSONNEL TRAINING AND SUPPORT: The variable cost of initial and replacement training (training pipeline), moving and health care of personnel. Includes contractual support.

307.1 Individual Training: The variable cost of recruit, technical (skill), undergraduate pilot and undergraduate navigator training, including the pay of training pipeline personnel, and the cost of their instruction (including instructor pay). (See Note 6.)

307.2 Health Care: The variable cost of providing medical support to deployed units, below depot maintenance, installation support and training pipeline including the pay of medical personnel who provide this support, and the cost of medical materiel.

307.3 Personnel Activities: The PCS costs of: deployed unit, below-depot maintenance, installation support, training pipeline and medical personnel.

307.4 Personnel Support: The cost of supplies, services and equipment needed to support training pipeline and medical personnel. Examples of included costs are: administrative supply items, travel expenses, expendable office equipment and machines, custodial services, and other variable personnel-oriented support costs incurred at training centers and medical facilities.

308 SUSTAINING INVESTMENTS: The cost of procuring spares, modification kits and materiel, ground support equipment and training ordnance needed to sustain deployed unit peacetime operations, exclusive of WRM costs.

308.1 Replenishment Spares: The cost of procuring aircraft assemblies, spares and repair parts that are normally repaired and returned to stock. In addition, this cost can include procurement of stock levels that are not provided by initial spares procurement.

308.2 Modification Kits and Materiel: The cost of modifying aircraft, ground equipment, and training equipment in the operating inventory to make them safe for continued operation, to enable them to perform mission-essential tasks (not new capability), and to improve reliability or reduce maintenance cost. Includes spares for modified equipment.

308.3 Replenishment Ground Support Equipment (GSE): The cost of replenishing common ground servicing equipment, maintenance and repair shop equipment, instruments and laboratory test equipment, and other equipment including spares for these equipments. Covers such items as ground generators; jet engine stands; test sets for radios, radars and fire control systems; hand tools; compressors; gauges and other minor items. These equipment demands are generated by a need to: (1) replace peculiar support equipment bought using aircraft procurement funds; (2) obtain common off-the-shelf ground equipment needed to support aircraft operations as production aircraft arrive in the operating inventory; and (3) replenish common ground equipment no longer usable.

308.4 Training Ordnance: The cost of replacing or increasing stocks of training ammunition, bombs, rockets, missiles, and sonobuoys expended during peacetime flying operations.

308.4.1 Munitions: The cost of munitions (live and inert) expended by the operating unit for the purpose of sustaining aircrew proficiency in weapon delivery techniques.

308.4.2 Missiles: The cost of missiles (live and inert) expended by the operating unit for the purpose of sustaining aircrew proficiency in weapon delivery techniques.

308.4.3 Sonobuoys: The cost of sonobuoys used during peacetime.

NOTES:

1) Factory training provided by contractors at their facilities to qualify an initial cadre of skilled personnel to: (1) operate and maintain a weapon system when operationally deployed, or (2) initially man the Services' weapon system-related training courses. Contractor instructor pay and the cost of instruction at contractor facilities are categorized as investment costs; the pay of Service military and civilian personnel attending the factory schools is an O&S cost.

2) The distinction between initial spares, which are defined as a support investment cost, and replenishment spares, which are considered part of O&S, is one of convention. Any comparison of alternatives should address total spares requirements: the sum of cost elements 202.4 and 301.1.

3) If the unit operates weapon systems in addition to the type being evaluated, create a typical unit to represent the manpower and expenses required for deployment of the aircraft of interest, and explain how the costs were derived.

4) In the Army, below depot maintenance includes all manpower authorized in aviation unit maintenance (AVUM) and aviation intermediate maintenance (AVIM) units. Manpower in units which support more than one type of aircraft should be estimated on the basis of relative workload. In the Navy, below depot maintenance includes all manpower authorized in the squadron maintenance department, the Air TAD (temporary additional duty) and an estimated share, based on relative workloads, of the manpower of the aviation intermediate maintenance department of an aircraft carrier or air station. In the Air Force, below depot maintenance includes manpower authorized in the wing for the chief of maintenance, quality control, maintenance control, and aircrew life support sections; those authorized in the organizational field and avionics maintenance squadrons; and those assigned in the munitions maintenance squadron.

5) Include contractor logistic support costs for the appropriate aircraft system.

6) Factory training provided by contractors at their facilities to qualify an initial cadre of skilled personnel to: (1) operate and maintain a weapon system when operationally deployed or (2) initially man the Military Department's weapon systems related courses. Contractor instructor pay and the cost of instruction at contractor facilities is categorized as an investment cost; the pay of Service military and civilian personnel attending the factory schools is an O&S cost.

APPENDIX B

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DoDD 5000.2	"Major System Acquisition Process." January 18, 1977.
DoDD 5000.3	"Test and Evaluation." January 19, 1973.
DoDD 5000.4	"OSD Cost Analysis Improvement Group." June 13, 1973.
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Deputy Secretary of Defense Memorandum for the Secretaries of the Military Departments. "Reduction of Outyear Operating and Support (O&S) Costs." February 28, 1976.

2. ORGANIZATIONS

a. OFFICE OF THE SECRETARY OF DEFENSE

- Director, Planning and Evaluation (OSD(P&E))
- Director, Acquisition and Support Planning (OASD(I&L))

b. DEPARTMENT OF THE ARMY

- Director of Cost Analysis, Office of the Comptroller of the Army (DACA)

c. DEPARTMENT OF THE NAVY

- Cost Analysis Advisor, Systems Analysis Division, Navy Program Planning Office (OP-96D)

d. DEPARTMENT OF THE AIR FORCE

- Director of Management Analysis, Office of the Comptroller of the Air Force (ACM)

APPENDIX C

GLOSSARY OF USEFUL TERMS

Conceptual Design—That stage of the conceptual phase wherein the alternative candidate systems defined by feasibility studies are verified as feasible and further refined and a conceptual baseline is prepared for DSARC review. Initial resolution of identified technical risks is made.

Conceptual Phase—That phase of the aircraft design process that defines a series of feasible designs and results in the selection of one or more candidate systems whose principal performance and cost characteristics are defined. The conceptual stage consists of Feasibility Studies and the Conceptual Design.

Contract Design—That phase of the aircraft design that results in an allocated baseline suitable for Milestone II or III and provides the documentation required for the aircraft to be contracted for.

Cost Analysis Improvement Group—An advisory body to the DSARC on matters related to cost. (DoDD 5000.4)

Defense Systems Acquisition Review Council—An advisory body to the Secretary of Defense on the acquisition of major defense system programs and related policies. (DoDD 5000.26)

Design to Cost—A management concept wherein rigorous cost goals are established during development, and the control of system costs (acquisition, operation and support) is achieved by practical trade-offs among operational capability, performance, cost, and schedule. Cost, as a key design parameter, is addressed on a continuing basis and as an inherent part of the development and production process. (DoDD 5000.28)

Decision Coordinating Paper—A document that defines program issues, including special logistics problems, program objectives, program plans, performance parameters, areas of major risk, system alternatives and acquisition strategy. (DoDD 5000.1)

Feasibility Studies—The first stage of the conceptual phase, where a series of designs is defined and compared to operational and cost constraints, leading to the selection of one or more candidate systems. Major technical risks are defined.

Life Cycle Cost—Total cost to the government of acquisition and ownership of a system over its full life, including the cost of development, acquisition, operation, support, and where applicable, disposal. (DoDD 5000.28)

Maintainability—A characteristic of design and installation expressed as the probability that an item will conform to specified conditions within a given period of time, when maintenance action is performed in accordance with prescribed procedures and resources. (MIL-STD-721B)

Navy Resources Model—A model used to estimate resource requirements required to support Navy ships and aircraft for use in the Five Year Defense Plan and to estimate the dollar and manpower resources required to operate or acquire a single ship or aircraft.

Operating and Support—Those costs associated with the maintenance, logistics support and operation of a system over its life.

Preliminary Design—That phase of the system design process where the selected design is further defined and hardware and system characteristics are selected and refined. A functional baseline is prepared for DSARC review.

Reliability—Probability that materiel will perform its intended function for a specified period of time under stated conditions. (DoDD 5155.11)

Subsystem—A major functional grouping of weapon system components or equipments, e.g., Propulsion System.

Support Investment—One-time costs associated with a weapon system that are required in order to ensure that the planned support of that weapon system is achieved. It includes initial spare and repair parts, facilities investment, special tools and test equipment, initial training in the operation and maintenance of the system, and documentation and software required to maintain the weapon.

System—A complete weapons system, i.e., an aircraft.

Visibility and Management of Support Costs—An effort to establish management information systems that will identify the direct and appropriate indirect costs of supporting individual weapon systems, with particular emphasis on the maintenance function. (DoD–MBO–9–2, 1975)

APPENDIX D
ABBREVIATIONS

AAW—Anti-Air Warfare

ASD (I&L)—Assistant Secretary of Defense for Installations and Logistics

ASUW—Anti-Surface Warfare

ASW—Anti-Submarine Warfare

CAIG—Cost Analysis Improvement Group

CES—Cost Element Structure

CNO—Chief of Naval Operations

DCP—Decision Coordinating Paper

DSARC—Defense Systems Acquisition Review Council

FYDP—Five Year Defense Plan

GFE—Government Furnished Equipment

IMA—Intermediate Maintenance Activity

LCC—Life Cycle Cost

MLSF—Mobile Logistic Support Force

MSR—Maintenance and Support Requirements

NARM—Navy Resources Model

NBC—Nuclear, Biological, Chemical (Warfare)

O&S—Operation and Support

OSD—Office of the Secretary of Defense

SecDef—Secretary of Defense

SI—Support Investment

SPDS—System Program Definition Statement

VAMOSC—Visibility and Management of Support Costs

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As weapon system life cycle costs have risen,

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The DoD, Military Departments and defense contractors have for some time been actively concerned about rising life cycle costs (LCC) of Defense weapon systems.

Over the past two years, DoD has placed new emphasis on examining the operating and support (O&S) cost impacts of planned new weapons and finding ways to reduce these costs. O&S cost analyses are now a major part of the cost review conducted at each weapon procurement decision meeting by the Defense Systems Acquisition and review committee (DSARC) and the DSARC's principal advisor on

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new system costs > the Cost Analysis Improvement Group (CAIG).

This report recommends guidelines for preparing and presenting estimates of the support investment (SI) and O&S costs of fixed and rotary wing aircraft systems to ~~the~~ DSARC. It provides a framework for objective comparison of SI and O&S costs of program, design, or support alternatives, using consistent methodologies and terminology. It also focuses on ~~the~~ assessment of efforts to control ~~the~~ downstream costs of weapon systems in the acquisition phase. A general methodology for SI and O&S cost-estimating is described, a standard cost element structure is defined, and specific requirements for presentation of SI and O&S cost estimates to ~~the~~ DSARC are proposed. Standards for the presentation and documentation of those cost estimates are recommended.

These guidelines are intended to achieve consistent and effective preparation and documentation of major weapon system SI and O&S cost estimates, and to facilitate DSARC's and the CAIG's examination of important SI and O&S cost issues. They should be understood as recommendations to the CAIG -- a contribution to the preparation of an updated official CAIG Cost Development Guide for Aircraft Systems which was initially published in May 1974.

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